

From: Lucy Fielding <lcdf2@cam.ac.uk>
To: H.K.D.H. Bhadeshia <hkdb@cam.ac.uk>
Date: Mon, 30 Jan 2012 15:18:49 +0000
Subject: BADA Pictures

MIME structure of [this message](#), including any attachments:

1. Multipart:
 1. [text/plain, 59 lines](#) [Download this text](#)
 2. [text/html, 52 lines](#) [Download this text](#)
 2. [BADA for Harry.zip application/zip 31674 KBytes](#)
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Part 1.1:

Dear Harry

Please find attached the first lot of pictures from the two BADA alloys. I have not been able to get good images of the exit edge as yet because it keeps getting rounded off too much while polishing. I may try to mount the sample in Bakelite and try again that way. I have indicated the orientation of the images using the co-ordinate system you suggested in your last email.

Most of the images are of the shear bands at the projectile entry point, although I have also included some other features (e.g. where the Mn-rich steel has cracked on the edge of the hole - I do not think this was caused by cutting or grinding) and some micrographs of the bulk material for comparison. Both steels show quite marked segregation and it is visible with the naked eye once the material is etched. The segregation is actually quite useful though as it makes it much easier to see where there has been some shear in the material even when the shear band is extremely thin. It also helps to visualise how the material at the edge of the hole has moved relative to its original position. With some of the larger montages it is possible to see the depth of material that has been deformed.

I am still working on getting some images of the exit points and other areas of interest but I thought you would be keen to see the first set of opticals.

In other news...

I expect to finish the x-ray scans of the Charpy specimens this week - I did a test with some carbon tape and that seems to work, there is a broad peak around 41 degrees but Mathew thinks it shouldn't affect the Rietveld analysis.

I have more Charpy specimens currently being machined. Once they arrive I shall do another test to measure deflection and then I can get the load-deflection curves out and compare absorbed energy with that of the proper Charpy tests.

I have a huge number of TEM pictures for 200C, 250C and 300C transformations of the superbainite and I hope they will be sufficient to get some good measurements for the bainite plate thickness, although I am

not certain about the sample at 250C where there seem to be more blobs than plates. However Mathew reassures me that his samples looked like that as well so I will have to see what I can get out of them.

I am still working through some books and papers about modelling stresses at the notch. I have narrowed down an equation which seems to be valid for the Charpy loading conditions, although it only applies over the length of the plastic zone. I am also uncertain of its validity in the situation where we have austenite transforming to martensite and strain-hardening the material, as many of the analyses neglect local hardening in the notch region.

I think that's it for now!

Lucy

Part 2: [BADA for Harry.zip application/zip \(31674 KBytes\)](#)

From: Lucy Fielding <lcdf2@cam.ac.uk>
To: H.K.D.H. Bhadeshia <hkdb@cam.ac.uk>
Date: Mon, 30 Jan 2012 16:33:19 +0000
Subject: Re: Dinner

MIME structure of [this message](#), including any attachments:

1. Multipart:
 1. [text/plain, 51 lines Download this text](#)
 2. [text/html, 54 lines Download this text](#)
 2. [Bulk Ni.jpg image/jpeg 928 KBytes](#)
 3. [Bulk Mn.jpg image/jpeg 792 KBytes](#)
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Part 1.1:

Hi,

See attached images of the structure well away from the damage (centre of the plate and section). I took some while doing the original microscopy and the microstructure seemed unchanged until the very edges of the material. One interesting feature is the thick segregation band running down the centre of the Mn-rich sample. I originally thought it was some feature of manufacture (maybe from casting, since it's in the centre?) but am not sure why it has only affected the Mn sample except for the argument that Mn does segregate more readily.

Microhardness I can also try, I think there are enough bands to give me a decent area to work with.

Other than composition and having the actual plates, I have no information about this alloy at all. I have asked Peter Morris who said I should ask Brown/Baxter as they did the original experiments and he doesn't know what results they got. He said you might have contact details for Brown. So we can perhaps find out a ballistic mass efficiency.

Lucy

On 30 January 2012 15:57, H.K.D.H. Bhadeshia <hkdb@cam.ac.uk> wrote:

> Lucy - can you also provide photos well away from the damage, with exactly
> the same etching conditions. I need to see what is microstructural banding
> as present in the original material, and shear bands. What amazes me is the
> lack of profuse cracking, but I have to admit, this is the first time I
> have seen something like this.
>
> I am surprised by the amount of ductility in both materials.
>
> The shear bands are, I guess, the curvy bits. The segregation bands are
> most clear in the Mn alloy as one might expect since Mn is much more prone
> to segregation.
>
> Do you think it is possible to do microhardness tests at and near the
> shear bands?
>

> We eventually will need to take a specimen from the shear band using FIB,
> for TEM.
>
> I am going to bed now, but I will mull over these tomorrow and give you
> some more feedback if I have sensible comments.
>
> Do we know whether these alloys performed well as armour? Do we have a
> ballistic mass efficiency?
>
>

Part 2: [Bulk Ni.jpg image/jpeg \(928 KBytes\)](#)

Part 3: [Bulk Mn.jpg image/jpeg \(792 KBytes\)](#)

From: H.K.D.H. Bhadeshia <hkdb@cam.ac.uk>
To: Lucy Fielding <lcdf2@cam.ac.uk>
Date: 31 Jan 2012 01:00:19 +0000
Subject: Re: BADA Pictures

I think it is excellent and I would be excited to see whether the scale justifies this faster transforming material in being called "superbainite". Also, is there any sign of martensite in the structure, or only bainitic ferrite and austenite? Can I see these?

> I have a huge number of TEM pictures for 200C, 250C and 300C
> transformations of the superbainite and I hope they will be
> sufficient to get some good measurements for the bainite plate
> thickness,

Regarding BADA, when you get some useful information from Peter Brown on the ballistic mass efficiency, I would like to understand the shear bands. The basic concept is that high strain rates lead to adiabatic heating and hence localise the deformation. So an elementary idea that I worked on a long time ago is that if the strength increases with temperature, then shear bands would be eliminated.

It would be useful therefore, to characterise the temperature dependent strength of both superbainite and BADA.

Is the material inside the shear bands martensitic, or simply very heavily deformed original microstructure? If the former, then those bands will have reaustenitised, and retarding that process should give better ballistic performance.