
Summary and Closing Remarks

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Phil. Trans. R. Soc. Lond. A 1976 **282**, 479-482

doi: 10.1098/rsta.1976.0061

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6. SUMMARY AND CLOSING REMARKS

MRS KIRSNER

As the only representative of the Rosenhain family here at this conference, I take this opportunity of thanking so many splendid people who have made possible a conference, dedicated to the memory of my father. Most of all I want to thank Dr Anthony Kelly whom I know has been thinking about this for many years. If you heard his fine Centenary Lecture I don't know whether you would agree with me but, being the daughter, it was very moving to hear my father presented in such reality, the character and his personality as well as some of his work. May I make one point about my dad, as he is to me still, I think had he known that such a conference as this were contemplated and in fact carried through, he would have been a little bit surprised, and very delighted, because as you may know his work was paramount. Scientific honours came to him in plenty, although he did not seek them, but this kind of honour, he would have been very delighted with. And so Mr Chairman, ladies and gentleman, I wish to convey my most sincere thanks and appreciation to all those people who have contributed, to all those people who have supported Dr Kelly and all the Societies that have given their support to this the Rosenhain Centenary Conference.

A. KELLY, F.R.S. (*National Physical Laboratory*)

Mr Chairman, Mrs Kirsner, Ladies and Gentlemen. This session was planned in order to summarize rather quickly, the points made in the discussion. Sir James has covered so well in his address a summary of the points made in the papers. I think that I have to summarize extemporaneously and rather quickly, and I should like to finish by thanking all those people who have contributed.

I must say I feel rather like the young churchman who was summoned early one morning, one Sunday, and told 'You are going to have to preach in the cathedral, because the Bishop has been taken ill and so have his various vicars; not only have you got to give the address in the morning, but you also have to give an address in the evening.' So he said, 'Oh, well, oh dear dear, so I have got to speak almost immediately without notes.' And they said, 'Yes, that's right.' So he said, 'Well, the only thing I can do then is just to get up and let God speak through me, and I will see if I can do anything better this evening.'

What struck me was that in the sessions on engineering requirements, there was pointed out (most particularly in the discussion) the need for tests for stress corrosion cracking, corrosion fatigue, and particularly for fretting; it is clear that there are needs for tests in these areas, and particularly tests in corrosive environments coupled with some form of rubbing of the surface. Professor Wells summarized a long discussion about what was needed beside the yield stress to define mechanical behaviour, and there were various suggestions made. For instance, ductility at the root of the notch (which one guesses must automatically involve some size effect, not always the same for different structures). Mr James in passing said we do need to consider costs, and costs then fell almost out of consideration until the last session. The only point I would make is that as everyone becomes more aware of the necessity to consider hard economic facts, we do need more detail on those hard economic facts. We do need to know in detail the factors influencing the final cost.

Mr Cotton brought home, very vividly to me at least, that there are three types of engineering structure being considered, when he said that with offshore rigs, one did not know the service environments. These three types of structures are: one, exemplified say by a bridge, discussed by Harper, where the general design requirements are known and the new types come about by economic pressure, say for instance, box girder bridges. The general engineering requirements are known, and the innovation or substitution comes essentially I think from cost effective motives. The second type would be the one discussed by Imrie; the undercarriage, where very precisely defined and clearly enunciable requirements have to be met, e.g. these were strength, toughness, cost, each very precisely defined. Now the third one, which I don't know whether as metallurgists, we had really realized before, are the offshore installations which are being put into service in a completely new set of environments. It was brought home that here one designed and had to build the thing, but did just not know many of the conditions under which such an enormously costly structure would be operating.

Then we went back and forth over high toughness and high strength, speaking of these as material parameters. But of course there are ideas emerging from mostly Professor Morley of Nottingham, who is not here, on designing toughness into a structure as an integral part of that structure; not just using a material parameter to obtain it.

Some of the later discussion was a little confused because people, when talking about tests, were not distinguishing clearly between quality assurance tests and tests for design.

In Session 2 which dealt with some of the design implications, there was a fascinating discussion of probability. I have been unable to see Flint again, who came up with it. I could not follow his argument. But he certainly amused us at the time, when he said that the greater spread in values of a parameter, e.g. strength, gave the greater reliability in the structure. I could not understand that, and I am afraid I have not been able to speak with him since. Hirsch intervened and supported the idea of the probability concept of failure, because, as he very clearly put it, it is (a) quantitative, and (b) can then be subject to risk analysis. But of course that must be predicated upon knowing the routes to failure, and as Leckie said, we must know the mechanism and it is best to be able to present that mechanism in terms of some form of constitutive relation.

We then passed on to consider corrosion monitoring and that leads me to suggest that there had been an earlier suggestion by Meetham from Rolls Royce that may be relevant here, namely that by watching the change of a microstructure, one may deduce something about service conditions. I wondered whether this would be useful either on the offshore oil rigs or in other applications. We have now the ability to watch even the effect of atomic motions, so that we are not limited only to high temperature changes; I wonder whether in fact by examination of failures and even of pieces put in there specially so as to be taken out later, one could not obtain a better idea of some of the campaigns conditions for a particular engineering structure.

One other point that emerged is that design, while very important of course, is not everything. One has to be sure that the design is in fact carried out, that the right material is used, and that mistakes are not made. One must design against failure to carry out the designer's specifications, and of course in one sense fracture toughness does that because besides specifying a stress, it also specifies certain types of inspection which must go with that stress in order to make it a sensible design parameter.

We then passed on to materials development, and there I was struck by the fact that the properties of steel are really remarkably well understood, in terms of grain structure, dislocation

structure and the different types of hardening mechanism. The locus of properties can be stated, although we may need tests for material in specific applications, as came out of Mercer's discussion – and also when Mr Clay answered a question from Mercer about how he had measured the stress in a linepipe, which involved Baurchinger effects in the steel.

In many cases the envelope of strengths is understood, and it is in other areas that more advances will be made. It seemed to me, as I said later in the meeting, that in that particular area of predicting static strength, physical metallurgy really has been very successful in (after 50 years or so) setting down what are the main properties contributing to strength. We still have not got such a detailed knowledge of fracture toughness.

I was struck by a remark from Pugh, who said some steels contain $\frac{1}{2}$ % of copper as impurity, and if I remember my metallurgy right, my extractive metallurgy, copper ores are exploitable if they contain 1 % of copper, so certain steels cannot be far off being useful sources of copper for extraction.

We then had a session on materials present, and future, and there one got the impression, or I did, from the papers and the discussion, that the very well developed titanium and aluminium alloys have in fact been developed – I think it was Nicholson who said it – using a phrase of Cohen's – by using the bank of knowledge, although one can not trace in many cases specific use of that bank. On the other hand, in the case of nickel alloys and the steels, the design seems to follow from recently discovered and clearly enunciated principles.

In addition, in that session, the effect of trace elements came out very very clearly, and the question of strength and toughness figures came up again. I wondered whether one could now predict limits for toughness in the same way as limits can be set on the strength under certain conditions.

Lastly, interface mechanics were noted as not being understood, and I think that interface mechanics (the concept was introduced in terms of grain boundary interaction) is of course central, not only to metallurgy but also to engineering because of joints, both welded joints and joints in structures. This leads into composite materials, and all of these subsume problems in the mechanics of interfaces.

We then passed to what I might call, if I may, a rather more philosophical part of the meeting, with discussions on education and I do not think I will attempt to summarize those, except to take one point from Sir James, when he emphasized the need for teams. That is what this meeting is all about; getting to know one another in order to form teams. I think there is, and I am sure a lot of other people do so too, one element leading to this necessity and that is the extreme complexity of modern technology. Because of the complexity, we are inevitably going to have to learn to live across one another's traditional boundaries.

Well, that is my imperfect summary of what I got from the discussion.

Now I think it just remains for me to thank everybody who has been involved in the conference. Personally I should say, despite Mrs Kirsner's very kind words, that this conference could not have been mounted at all without the help, particularly, of Dr Baker, and Dr Miles, and the many colleagues at N.P.L. who helped us. I would particularly like also to thank Miss Lambert from the Metals Society, Mr Tillotson from the Royal Society and Mr Hall of the Metals Society, as well as my own Director. We should thank Sir James Menter for the support he gave us from the start of the planning of the conference, and particularly, being such a busy man, for his presence for most of it and also for his paper. No man in his position could have done more to support us. I should thank all the caterers, and I must thank Mr Carrington and

Dr Miles for running the historical exhibition, and the Royal Society who will, in addition, produce the final proceedings. I should like to thank publicly Professor Hargreaves, who has presented the N.P.L. with a plaque to Rosenhain, which was in fact in the exhibition. I should thank the authors and the Chairmen. The authors have been most kind. They have done what authors seldom do at conferences nowadays. They have spent all the labour of writing excellent papers and then they have sat patiently and heard others discuss their work. I think for that alone we should give the authors one tremendous hand.

We should also thank the Chairmen who guided the discussions, and the Keynote Speakers. They did a great job. When the Keynote Speaker sits down the Chairman has to make sure that the meeting goes on for another hour and a quarter, but there has been no difficulty in that, good though the Chairmen and Keynote Speakers were, because you have been such a magnificent audience. And lastly, thanking Mrs Kirsner for coming all this way to see us, and reminding us so well that Rosenhain is not a long way away in time, I formally declare the meeting closed.