Appendix II

The Workshop

The Phase 2 Workshop was held at the National Motorcycle Museum on 2 March 2000. It was attended by 42 individuals representing most sections of the Consultation Community. Very few had taken part in interviews. The programme was constructed on the pattern used successfully in Phase 1. A panel of 'solution providers' commented on the role their organisations could play. Then participants divided into six syndicates to develop thinking on selected topics - Magnets, Environment, Government, Structural components, Centres of excellence, Education and training - each with a member of the Project Executive team as moderator. All then fed back to a plenary discussion session.

This Appendix contains a brief account from each syndicate of the discussions held and mentions the issues which had been raised in the consultation exercise in interviews up to that point, and which had been put to the syndicates These brief accounts, compiled immediately after the event, have been subject to minimal editing in order to give some flavour of the discussions.

Syndicate 1: Magnets (Neil Blyth)

A. FINDINGS PUT TO THE SYNDICATE

The Situation

Interviews confirmed that the following are important problem areas for the development of the UK magnets industry

- Nd-Fe-B (or an alternative system) with improved temperature and corrosion characteristics, coupled with lower manufacturing costs.
- Consistency and repeatability of magnetic and dimensional properties at minimum cost.
- Having UK producers with a market position where they can compete globally and profitably.
- Exploiting the potential for the rapid growth of powder technology in soft magnetic materials.

The Solutions?

- Develop improved materials based on the Nd-Fe-B system (or any new alternative system) against a performance and cost specification.
- Improve pressing operations through improvements to powders, die fill, compaction and handling.
- Identify existing and developing niche markets with high added value potential for UK manufacturers.
- Persuade UK PM companies to invest in the manufacture of magnetic components.
- Facilitate the design and manufacture of soft magnetic composites in the UK.

B. MAGNET WORKSHOP SYNDICATE PROPOSALS

The Workshop Magnets Syndicate members, having discussed the key early findings (the Situation), and considered the possible solutions to the problems/opportunities presented, developed some project proposals.

They are listed in priority order, reached by consensus, but there was the impression that there would be advantages in running them in parallel, with links.

1. Powder Handling and Pressing Improvements

Improve pressing operations through improvements to powders, die fill, compaction and handling. This would assist the drive to secure better consistency and repeatability of magnetic and dimensional properties at minimum cost, something which has been identified as being particularly important to end users. It would also assist producers in reducing costs through more efficient manufacture and lower material losses. Cost reduction would be an essential deliverable.

Not only should both soft and hard magnetic materials benefit, but there is also commonality with structural and other powder metallurgy parts where handling and compaction of powder materials requires improvement.

For this reason, it is suggested that cross sector collaboration is important in the project team. E.g. structural parts, ceramics, pharmaceuticals, etc.

Apart from the fact that a cross sector, multi-disciplinary team should undertake the project, it was not determined who exactly should be involved or who should lead the initiative, owing to lack of time at the Workshop.

2. Improved materials based on the Nd-Fe-B system (or any new alternative system)
Develop improved Nd-Fe-B type materials.

This project would be divided into two parts:

- Improvements to corrosion resistance
- Improvements to temperature performance

The consensus in the syndicate group was that corrosion is the most important of these, since even the best materials suffer with corrosion to some extent, and temperature performance has already improved substantially, and in at least some cases, can be compensated for by design changes.

Improvements to bonded magnets, especially ANISOTROPIC bonded magnets, should be included in the project; their potential has not yet been realised. Low cost manufacture would also need to be included as a project deliverable.

Most component introduction programmes are based on present cost of the individual parts. In the case of Nd-Fe-B, costs have reduced at 10-15% per annum for several years so we can expect the cost to be significantly less by the time the product goes into production, e.g. automotive lead times of 3 years.

The consensus view was that the University of Birmingham should do the development work, because of its existing expertise and facilities in the development of rare earth permanent magnets and its general net shape capability. It would form part of a project network, not defined at the Workshop.

3. Small Motor Development
Develop a small motor or series of small motors using both hard and soft magnetic bonded materials in an integrated system. The soft magnetic material would be an iron based composite and the hard magnetic material would be based on the bonded Nd-Fe-B alloy system, or an improved version of it.

This project would:

- Aid UK development of soft magnetic iron composites, these having been identified as having strong growth potential
- Promote/take advantage of improvements in the temperature and corrosion performance of Nd-Fe-B
- Take advantage of the strong market growth of bonded Nd-Fe-B.
- Utilise the existing expertise of UK organisations in magnet alloy manufacture, bonded magnets production, assembly, motor design, motor production, and research and development of hard and soft magnetic materials.
- Assist the efforts to determine good added value niche markets for UK manufacturing.
- Recognise that motors currently use a substantial amount of both hard and soft magnetic materials globally and that this cross-sector application still represents one of the best opportunities for further conversion to permanent magnet systems.
- Allow development of magnetic materials which are net shape and "recycling friendly" thus linking with industry environmental objectives.

The work should include the following automotive applications:

- Brushless dc motors for X-by-wire applications.
- Stepper motors and torque motors.
- 42 volt starter-alternators.
- Speedometer, tachometer and gauge drives.
- Speed and position sensors.

Since motors and sensors are cross sector applications, such automotive developments would facilitate similar developments in non-automotive sectors.

This project would be carried out by an UK Working Group (yet to be defined/identified) and comprise members of the industry supply chain (from raw material producer to end-user), motor design experts and materials experts from academia, etc.
Professor Alan Jack and his research team at Newcastle University should be included in the Working Group because of their experience in motors and soft magnetic composites (bonded iron).

Potential opportunities for other powder metallurgy products in motors would be explored as a part of the project.

Net shape (or as close as possible) would be a prime objective, to reduce process stages and hence cost.

Integrated manufacture would also be a deliverable.

It was noted that grant funding may be possible under an EPSRC "integrated development" scheme, but this requires investigation.

4. Fundamental Properties of Soft Magnetic Composites
Investigate the fundamental magnetic and physical properties of soft magnetic composites.

The magnetising behaviour of the materials is not well understood and there are existing problems of physical integrity, which will constrain their use unless solved.

A lot of emphasis has rightly been placed on getting soft powder composite production optimised, but little work has been reported on optimising or tailor-making suitable combinations of loss and permeability performance, or an optimised frequency/flux density operating range. This is where basic structures and production methods may need further examination.

Magnetic properties may also not be homogeneous within a composite core. This needs to be confirmed and if it's a problem, it needs to be addressed.

As with all projects, the advantages of teamwork cannot be over-emphasised and again some network or working group would need to be set up to drive it forward.
Both Cardiff and Newcastle universities should be included in the group because of their expertise in the soft magnetic material development.

C. FURTHER PROPOSALS
Feedback from the Magnet Syndicate members following the Workshop has not only resulted in improved definition of the solutions proposed and discussed, but has also generated two additional potential solutions/projects. They are:

5. Market Research
Search out appropriate applications and approach component companies (e.g. motors, sensors, etc.) in the automotive, industrial, computer peripheral and domestic equipment markets to demonstrate the potential for soft and hard powder magnet parts.

6. VehicleTraction Motors
Develop sintered Nd-Fe-B traction motors for vehicles.

There is a very strong case for the use of sintered Nd-Fe-B in traction motors in Electric Vehicles, Hybrid Electric Vehicles and Fuel Cell Electric Vehicles. These motors give smaller size, lighter weight and higher efficiency than alternative motors (induction or reluctance).

Permanent magnet cost currently makes them more expensive but this will change by the time large-scale production occurs. The other concern with permanent magnet motors is reliability and safety due to handling, attraction of metal parts and fault tolerance issues. Work on these is needed.

Lucas has developed a fault tolerant machine in collaboration with Newcastle University for the aircraft industry. This may be a basis for an electric vehicle motor.

Professor David Howe's team at Sheffield University are leaders in the design of permanent magnet motors for such applications. It therefore seems appropriate for the universities of Sheffield and Newcastle to be involved in such a project.

The UK has no manufacturers of sintered Nd-Fe-B components and this type of project could encourage UK manufacture (subject to patent considerations) of parts, particularly as UK manufacturers of alloy powders do exist, as do end-users.

Lessons learned from this project could be applied to larger motors in general outside of the automotive industry.

D. GENERALCOMMENTS
The above project proposals should not be regarded as entirely separate from one another. There is a great deal of synergy among some of them. For example, fundamental work on bonded iron would assist the development of the integrated manufacture of motors using hard and soft bonded magnets, improved Nd-Fe-B would aid the development of traction motors for vehicles, etc. Some developments could also have been placed in a different project category. An example would be anisotropic bonded Nd-Fe-B, which could have been incorporated in the small motors project rather than in the improved Nd-Fe-B project.

It may thus be appropriate to run some projects in parallel, with links between them, and perhaps with others identified from the PM Foresight Study, in some type of network arrangement.

Syndicate 2: Environment (Peter Brewin)

The syndicate took a Case Studies approach, indicating underlying issues:

Case Study 1
You are a primary material supplier. You are MD of the coy. 50% of your company output is an alloy containing TOXON. This is not known as a hazardous metal. Following a trip to Japan, one of your junior R&D engineers reports that a reputable Japanese lab has shown that TOXON in pure form causes tumors in rats. These early findings are being linked locally to recent unexplained human deaths in the local town, the factory of one of your main competitors
What do you do.
Some of the issues: publicity/additional testing/DPD (alloys versus mixtures)/ substitution/what data exist already/Monitoring

Case Study II
You are MD of a UK steel company employing 1500 people, this is the last remaining steelworks in the UK. In 2010 the government reviews the effectiveness of the 10% levy on electricity and fuel levied on industry in 2001 and decides it has had little effect. With strong public support following increasingly hot summers it is discussing putting a 50% tax on energy. At your then current energy consumption this would put your company out of business.
What do you do?
Some of the issues: role of Trade Associations; methods of lobbying; energy audits/new investment

It was felt that these Case Studies raised several key issues:

1. since the issues of the effect of metals on human health and the environment can be highly complex, it is important for UK manufacturers to be able to obtain expert advice. Centres of Expertise (universities, RTOs) could become increasingly important in this respect. It will be important that these are easy to find (e.g. good websites, some professional association.)

2. where key data is lacking, industry will have to generate this or face the consequences of uninformed and harmful legislation

3. since many of the laws are only currently being drafted, industry needs to have an effective method of lobbying

4. hitherto government has sought to find selected areas of research; it is possible that funds should also be directed towards health and ecotox testing of metals

5. advice centres should not only have good technical knowledge, but also good knowledge of legislation.

In the above it was felt that the following solution providers had essential roles:

- industry
- specialist research organisations
- trade associations
- universities with specialist centres
- EPSRC and similar funding bodies

Syndicate 3: Government (Brian Greenwood - DTI)

The following bullet points are extracted from a wide-ranging discussion which articulated some of the main concerns about interaction with Government, revealed likely DTI developments and highlighted the need for more coordinated action by TAs:

DTI

- More *focused* support from DTI - Requires both money and direction to enable support to be channeled to benefit the PM sector.
- Role for DTI is likely to be influenced by Foresight results
- Real results needed not just glossy publications
- DTI activities towards regionally based Manufacturing Centres of Excellence
- Manufacturing matters - DTI's manufacturing summit; knowledge driven economy
- DTI needs to more actively deliver tangible benefits to manufacturing industry
- More help for SMEs
- Regional Supply network, Business Link etc criticised for poor quality and relevance.
- DTI - more support likely from the new Small Business Service (SBS).
- Legislation on paying of bills needs to be enforced.
- Improve quality of existing and future services.
- E-commerce likely to be key feature of future DTI activity.

Improved climate for R&D investment

- Changes to taxation policy - matter for HM Treasury but role for TA and industry to lobby for specific changes
- Earmarked funding for PM from e.g. EPSRC, Link etc
- TAs to open dialogue with DTI (EID, OST), EPSRC etc on access to future funds for R&D, best practice etc

Trade associations

- TAs should collaborate more
- EPMA to develop links with e.g. CBM, SEA, Castings Sector etc on matters of mutual interest e.g. supply chain improvements, environmental matters, lobbying
- TAs to develop stronger lobbying initiatives EPMA and key member companies e.g. on issues such as CCL. Need to be involved early on and create better access to ministers via MPs etc

Human resources

- Quality of people - DfEE? Education, training and skills, including school leavers.
- TA (EPMA) to work with appropriate National Training Organisation (NTO) - to identify requirements, qualifications and assessment needs

Syndicate 4: Structural Components (Dr Geoff Greetham)

The Situation

FS2 confirmed that the following are important to the future development of the UK structural components industry.

- Improvements in component properties for more highly stressed, critical components
- Identification of niche markets
- Consistency, dimensional control and cost

The Solutions?

- Increase final density by development of materials, pressing technology, die lubrication and sintering technology.
- Add-in complexity by process innovation
- Process development to improve powder handling technology

Suggestions made:

1. To obtain acceptance of the need for higher density it would be sensible to put together an R&D program that showed precisely what the advantages were. This would be achieved, not by making components, but by producing high density test samples by any technology currently possible of producing them.

   It was suggested that the techniques would include:
   - Warm compaction
   - Rotary compaction
   - Hot isostatic pressing
   - Elastic die technology

   These samples would then be used to provide evidence for:
   - Ability to green machining complex shapes
   - Ease of joining by brazing and welding
   - Ease of surface finishing by electro-deposition
   - Ease of gaseous surface hardening techniques
   - Ability to produce composite components by co-sintering
   - Ease of sintering
   - Dimensional control and consistency

   There was debate on how this might be organised. It was agreed that a user should set any property targets for the PM samples. There would be a partnership between suppliers and customers, and Höganäs was suggested as a major player who would willingly agree to participate. A UK automotive company would be required, but which one? Nissan R&D at Cranfield was suggested as a possible collaborator as Nissan were committed to the UK for R&D facilities. Federal Mogul could also participate, but GKN would need to go through their European R&D Centre at Krebsöge. As design engineers, Ricardo and possibly MIRA were suggested as collaborators.

2. Simulation of the design of a component by forging and PM technology as a joint process was suggested. It was also commented that such a project was being considered and was relatively easy.

3. The medical industry was suggested as a possible source of disposable items suitable for production by PM.

4. Flexible manufacturing was suggested as a possible means of producing small batch sizes.

5. Nottingham has a Teaching Company Scheme with Aida Bliss (press manufacturer) for the development of innovative forming processes for the production of powder in strip and bulk. They need other partners. Could these be DTI, EPMA? (P Standring invited a talk with AB to consider possibilities).

Additional points:

6. The US government supplied several million dollars to MPIF to produce PM test data for industry. Why cannot we do the same?

7. Provision of test data is very important. The US and Japanese attitude is, after deciding to make a component, to put down testing equipment to prove the technical viability of the component to the end user. The UK attitude is to suggest making a component without back-up data and pray that the user will test it. There are then problems when situations arise in which the component fails and there are no test data to show which was the component changes (design, materials) should go.

8. P Standring and Diane Mynors (Brunel) have a joint EPSRC proposal outstanding. If funding is obtained they believe that they will be able to get to every design engineer in the country and inform him/her about near net shape processing, including PM.

9. Asked not to forget that MIM is a process already available for the production of high density, complex components. (GG note: This needs cheaper powder, hence must talk to Osprey again about prices).

Syndicate 5: Centres of excellence (Steve Harmer)

The situation
PM 2 has confirmed that for the UK Powder Metallurgy Industry to grow and prosper the following requirements must be satisfied. They apply to structural and magnetic components.

- Train and educate staff and workforce to the highest standards on a continuing basis. This crosses with the group talking about education and training.
- Maintain and develop awareness of global current developments and best practice.
- Promote cross fertilisation between different powder processing sectors.
- Promote the teaching of the technology to students of materials and engineering in universities and colleges.
- Make potential users of PM components, and all of the supply chain, aware of the technology, its advantages and limitations.
- Further to know where to seek and obtain advice and help on
- Technical
- Environmental
- Other topics that impact on them, their business and their customers.

The Solutions?
The UK has a large fund of knowledge and experience that could respond positively to many of these concerns and, if necessary, provide the physical and intellectual resource to generate the answers.
This is located, at least in part, within

- Trade associations e.g. EPMA.
- Learned societies e.g. UK Magnetics Society, IoM, IMechE etc.
- Universities e.g. Nottingham Network, the IRC at Birmingham etc.
- The PM companies.
- Individuals and consultants

We might call this the PM Expertise Pool.
To bring people with problems and people with answers together requires

- A definition of and map or plan of the Pool.
- A simple means of consulting the Pool.
- Mechanisms for the lateral transfer of technology between different PM sectors. (Benchmarking clubs?)
- An activity, appropriately equipped, for the 'off the job' training of the workforce.
- An activity, appropriately equipped, to conduct and co-ordinate PM R&D activities.
- Best Practice Guides or something similar that will work within the industry and also for potential users.

In discussion, it was agreed that CEs were a good thing and highly desirable but better definition was needed and it was suggested that such definition should be part of the task of the Project Executive for the

present exercise. (e.g. 'An adequate pool of teaching, research, people, facilities to provide advancement and progress..') European models exist (Grenoble, Madrid, Trento, Fraunhofer mentioned). If the field is considered as 'particulate materials', then e.g. Chemical Engineering at Cambridge, Oxford, Birmingham are CEs. Collaborative effort on specifics is needed.

Tasks

1. Audit of UK particulate processing expertise and identification of gaps (Foresight proposal extending from present exercise and adding ceramic, pharmaceutical expertise?)
2. Devise a virtual organisation as a nucleus for a CE (IoM?, EPMA?..)
3. Good practice guides; knowledge management for non-specialists; all maybe in broader context of NNS forming technologies (NPL, IoM, EPMA....leading on from task 1)

Syndicate 6: Education and training (Bob Wood)

Background

Interviews revealed that:

- While there may be a general view that education and training range from being a 'good thing' to being absolutely essential, there is less conviction that specifics are available coherently and effectively for PM
- The UK clearly plays a full part in amassing knowledge and information, but there is some doubt that the store of wisdom is usefully understood and applied

Summary of problems and routes to solutions

From the PM viewpoint, the education question in its broadest sense is seen as having three components:

1. Awareness of the PM route, its advantages and its potential
2. Courses, training after full time education
3. Formal, especially tertiary, education

Workshop discussion saw two main common aspects:

AWARENESS

ACCESS TO EXPERTISE

and drew attention to considerable concern that too much emphasis was placed on approaches to graduate engineers and far too little to the requirement for education and training of skilled operators/technicians; for example industry has a problem in the area of press setters.

1. Awareness: The question recurs: how is the design engineer to be made more aware of PM? This point was particularly stressed in Workshop discussion. Also:
   Awareness shortcomings are not confined to the design engineer:
   How are investors to be persuaded of advantages/development potential?
   How are legislators to be persuaded of the way in which PM can respond to e.g. environmental demands?
   Solution: Collaborative production of promotional material tailored per target? MIS Design Guide needed?

2. Courses: A demand for applied and practical courses is revealed, but given the very small numbers of people involved, how can these be designed and delivered economically and effectively.
   It has been said that the provision of education and training should be more responsive to demand in terms of
   - the kind of provision
   - the time of provision

   Solution: is the bulk of the demand likely to be better satisfied by collaborative development of distance learning techniques and material?

3. Formal: It is not seen as likely that anyone would 'take a degree in PM', but it is thought that undergraduate courses might include more of relevance to forming processes, especially near-net shape processes. Magnets are seen to be a growth area, but young graduate engineers are not likely to have been taught a lot about the technologies involved

Solution: Is there a way in which full-time education could take more account of technological developments by establishing a system of industry consultation?

Solution providers and their roles

It is self-evident that the educational establishments have some role, but so also do the trade associations and the learned and professional bodies. It is, however, feared that this obvious supply-side for solutions is very fragmented: many trade associations, many universities (34 claim greater or lesser expertise/interest in PM), many institutions.

Strictly speaking, all these organisations, as well as companies, should have an interest in solution provision, but leadership of task forces or consortia is required. Workshop discussion suggested that the Institute of Materials and the EPMA UK Chapter should be invited to get a small consortium together to:

1. assess the market requirement for type and content of courses
2. initiate course provision
3. ensure quality control for material, especially that used in distance learning via the Internet or otherwise.