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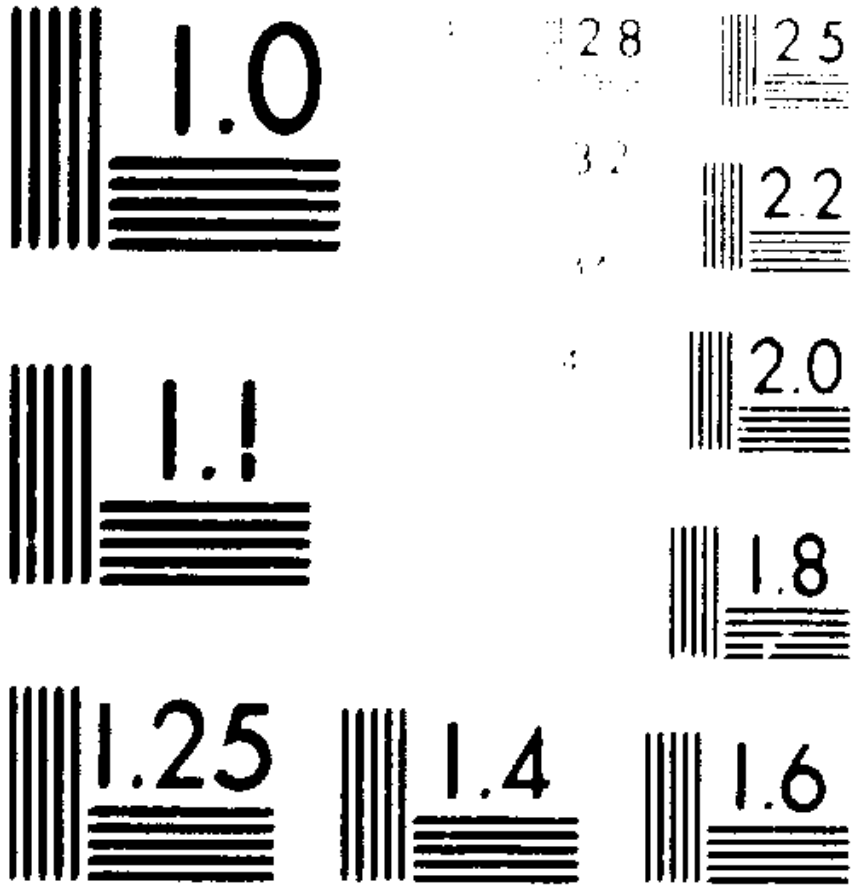

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Confidential Report

METALS ADVISORY SERVICE, PHASE II, ACTIVITY 2

PROJECT DP/PAK/77/018, UNIDO CONTRACT 78/63

FINAL REPORT

by

P.D. Caton

R795/10/March 1981

FULMER RESEARCH LABORATORIES LIMITED

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ABSTRACT

This report summarises the work carried out by Fulmer Research Laboratories between October 1978 and December 1980 on UNIDO Contract 78/63. The objectives set to provide technical instruction and advice to Metals Advisory Service, Lahore, Pakistan have been successfully achieved. The use of equipment supplied to MAS by UNIDO has been demonstrated and new casting techniques have been introduced. Delays in Pakistan, however, have meant that the full programme of training of MAS staff at Fulmer's home laboratories could not be completed during the lifetime of this contract. Whilst MAS is now in a position to provide assistance to Pakistan's metallurgical industry its success or failure will depend largely on the performance of its staff. The Fulmer specialists were alarmed by the lack of enthusiasm and high rate of absenteeism shown by some MAS personnel during the closing stages of the contract. The management of MAS must show a strong sense of leadership and authority to prevent disruptive elements from undermining the future viability of this potentially important venture.

CONTENTS

1. INTRODUCTION

Between 1975 and 1977, Fulmer Research Institute provided technical assistance to UNIDO Project DP/PAK/73/033 which established a "Metals Advisory Service" facility as an independent unit located within the premises of the Pakistan Industrial Technical Assistance Centre (PITAC) in Lahore. At the end of this first Phase, the scope of MAS had widened to the extent that Phase II was divided into four Activities.

There were broadly as follows:-

1. Special steels
2. Foundry techniques
3. Cokeless cupola
4. Direct reduction of iron ore.

Of these, a contract to carry out Activity 2 was awarded to Fulmer by UNIDO in 1978 and subsequently ammended in 1979. The Assistance to MAS was to be on similar lines to Phase I, i.e. provision of the services of a number of experts in different fields to give advice at the MAS laboratories and instruct the counterpart staff in techniques and the use of equipment, provide a back-up from the home offices to the staff serving in the Project Area, and to accept MAS personnel for training at Fulmer Research Institute. The programme covered a very wide area; from cast iron to lost-wax casting, from sand testing to ultrasonics, from wet chemistry to X-ray diffraction, and from shop floor demonstrations to techno-economic surveys. Seven people were assigned to give the Project Area service and, following some delays in Pakistan whilst MAS moved into new purpose-built laboratories, the full Project Area programme was successfully completed in December 1980. All the equipment has been demonstrated and new techniques such as S.G. iron production and shell moulding introduced. Problems in obtaining clearance from the Pakistan government meant that only Mr. M. Mansoor Ali received training at Fulmer during the duration of Phase II. Mr. Zubair Malik (chemical anlysis) and Mr. Iftikhar Ali (mechanical testing) could not be given training before December 31st 1980.

This report summarises the work carried out by Fulmer Research Institute. For detailed reports of specific activities the reader should refer to the Progress Reports R795/1 to 8. (See Appendix I).

2. OBJECTIVES

The objectives behind the involvement of UNIDO in the MAS Project were to assist the Pakistan Government (in the form of its Ministry of Industries) to establish a Centre for Metallurgical Expertise in Pakistan. The 'Centre' would provide technical information, advice and practical instruction to enable the Pakistan metallurgical industry to improve their productivity and the quality of their products and to introduce modern techniques. To this end, UNIDO has provided a substantial inventory of equipment (furnaces, rolling mill, foundry equipment, analytical instruments etc.) The Pakistan Ministry of Industries has provided first temporary then permanent purpose-built laboratory buildings and engaged a number of scientific and supporting staff to provide the service to industry.

During the first Phase of the Project, UNIDO awarded a Contract to Fulmer Research Institute (now Fulmer Research Laboratories) to provide the technical assistance required to help establish the Laboratory and train the personnel in the operation of equipment and the procedures for undertaking metallurgical investigations and providing advice to industry. Because of the widening of the scope of Phase II it was divided into four separate Activities with the Contract to carry out 'Activity 2' being awarded once more to Fulmer.

As far as the involvement of Fulmer Research Laboratories in Phase II of the Project was concerned, the objectives defined in Paragraph 1.01 of the Contract Document (UNIDO Contract 78/63, 11th September 1978) were as follows:-

a) supervise and conduct the technical studies and tests aimed towards the use of local sands and bentonites for foundry purposes;

b) supervise and conduct the technical studies on the production of nodular cast iron;

c) supervise and conduct a programme towards introducing investment casting, and precision casting techniques, and carry out studies towards using locally-available materials for producing various binders used in the processes;

d) train counterpart personnel on choice of foundry material, moulding and melting techniques and techno-economic evaluation of projects;

e) provide expert technical advice to local foundries and metallurgical enterprises and to supervise their implementation including shop floor demonstrations;

f) advise on quality control in foundries;

g) conduct specialist technical seminars;

h) advise the local metallurgical enterprises on their proper product mix so as to meet their actual requirements and to improve their profitability;

i) conduct economic evaluation(s) of project services and specialised technical seminars in this field;

j) operate instrumental chemical units; particularly spectrophotometers, spectrographs, X-Ray and non-destructive testing units and thermal testing units;

k) provide training of counterpart personnel on the operation and maintenance of the equipment under j) and the interpretation of the results.

In order to carry out these objectives, the Contract initially provided for 10 man months of Project Area Service, 12 months of "Home Office Service" for training and undefined "Home Office Support Service" (Backstopping). However, following the first visit of the Fulmer Team Leader in October 1978, during which discussion with the UNIDO Project Manager established that the Project Area Service was too short, the Contract was amended to provide 12 man months of Project Area Service.
Whilst the tender put forward by Fulmer proposed 12 months of counterpart staff training at Fulmer's home laboratories and this was the period written into the contract in its original form (para. 2.02 b) of UNIDO Contract 78/63, 11th September 1978) the amendment No.1 issued on 16th November 1979 reduced Fulmer's committments to 10 months. However, Fulmer has been prepared to accept trainees for the full 12 months but obviously with slightly reduced intensity of training.

3. ACTIVITIES CARRIED OUT

The mechanisms to achieve the objectives defined in paragraph 1.01 of the Contract Document were divided into three broad catagories:-

1. Project Area Service
2. Backstopping Service
3. Training at Home Office

3.1 Project Area Service

The main emphasis was naturally placed upon the service in the Project Area since this exposed the greatest number of MAS personnel to the influence and instruction of the Fulmer specialists. An interesting feature of this Project (which it is understood was rather unusual for UNIDO) was that because of its complexity it was clearly impossible for one person to provide the complete range of instruction. A team of seven experts (See Appendix III) was therefore selectedby Fulmer with their activities coordinated by one of them to be known as the Fulmer Team Leader. The way in which this team successfully covered the range of the objectives is shown in Table 1, (which uses the same identifying letters as given in the Contract Document and Section 2),and Appendix III.

TABLE 1

Assignments of Fulmer Team

	Objective Title	Personnel Involved
a)	Sands and bentonites	P.D. Caton, R. Lee, E. Selcuk, T.J. Veasey
b)	Nodular cast iron	R. Lee
c)	Precision casting	P.D. Caton, E. Selcuk
d)	Material selection/ Techno-economic	P.D. Caton, R. Lee, E. Selcuk, T.J. Veasey, /D.G.S. Davies
e)	Technical advice etc.	P,D. Caton, R. Lee, E. Selcuk
f)	Foundry quality	P.D. Caton, R. Lee, E. Selcuk
g)	Seminars	P.D. Caton, R.L. Crocker, R. Lee E. Selcuk, T.J. Veasey
h)	Product mix	D.G.S. Davies
i)	Project services	D.G.S. Davies
j)	Analytical instruments	R.L. Crocker, D. Nicholas, T.J. Veasey
k)	Training (Home Office)	Under supervision of P.D. Caton and D. Nicholas.
	Team Leader, P.D. Caton	

These objectives were spread over the 12 man months of service roughly as follows:-

8 months on foundry techniques and related activites.

3 months on use of analytical and test equipment.

1 month on product mix and project evaluation.

The bulk of the work was carried out at the MAS laboratories in Lahore, firstly at the temporary location within the premises of the Pakistan Industrial Technical Assistance Centre (P.I.T.A.C.) and later at the purpose-built laboratories at Kot Lakhpat on the outskirts of Lahore. However, when appropriate, time was spent at the works

premises of a number of metallurgical enterprises to gather information, give advice and carry out shop floor demonstrations.

The nature of the activities took on a number of forms as appropriate to the different needs of the objectives. These can be broadly summarised as follows:-

1. Commissioning and demonstrating use of MAS equipment.
2. Instructing MAS personnel in the use of equipment.
3. Instruction on analytical and test techniques.
4. Instruction on foundry techniques.
5. Advice on selection of materials and tests for evaluation and quality control.
6. Investigating industrial problems and advising ways and means to overcome and prevent recurrence.
7. Carrying out shop floor demonstrations.
8. Giving specialist seminars.
9. Preparing surveys and analysing results to provide advice on product mix.
10. Advising on running of MAS services.

The main features of the Project Area Service Programme are as follows. For a full description of the activities the reader is directed to the eight Progress Reports R795/1 to 8. (See Appendices I to V)

3.1.1 Sands and bentonites

During Phase I, Fulmer initiated a programme to evaluate a large number of Pakistan sands and bentonites and instructed MAS personnel on the necessary tests relating to their use for foundry mould making. At that time some of the tests could not be carried out at MAS due to the lack of suitable test equipment. During Phase II however, a complete sand testing laboratory was delivered to MAS, and this was set up by Dr. Selcuk and Mr. Lee and put MAS in a position to carry out all the tests themselves. For the evaluation of bentonites, further more specialised test techniques are necessary. These include X-ray diffraction, thermal analysis and cation exchange capacity. These technqiues were demonstrated to MAS personnel by Dr. Veasey;

details are given under paragraph 3.1.10. Instruction was also given on the use of local sands for precision casting; details are given on the appropriate paragraph 3.1.3. (See Reports R795/5, R795/8).

3.1.2 Nodular cast iron

Whilst experiments on the production of nodular (S.G.) cast iron had been carried out during Phase I, these were of limited scope due to the shortage of suitable specialised materials and lack of suitable melting furnaces. Great attention was therefore given in Phase II to ensuring that the Radyne medium frequency induction furnace was commissioned at the new MAS laboratories before the relevent expert, Mr. R. Lee, arrived to carry out his programme. Similarly, suitable quantities of nodulariser and inoculant for both laboratory and shop floor demonstrations were procured and shipped to MAS. The laboratory scale demonstrations were carried out during Mr. Lee's first period of Project Area service between March and May 1980. Since high purity pig iron was not available, low sulphur base iron was made by re-carburising steel scrap. Also during this period, Mr. Lee supervised the construction of an oil-fired furnace at MAS to provide additional melting capacity and a crucible pre-heating facility. During Mr. Lee's second visit between October and December 1980, a quantity of low sulphur, phosphorus and maganese pig iron was located at Ittefaq Foundries at Kot Lakhpat, Lahore. This was used to prepare a 1 tonne melt of nodular iron in their mains frquency induction furnace thus demonstrating the procedures on a full industrial scale. (See Reports R795/3, R795/6, R795/8).

3.1.3 Precision casting

The processes covered by this title included investment casting (lost-wax process) and shell moulding (Croning Process). Whilst it is understood that isolatated attempts have been made by a small number of Pakistan foundries to establish shell moulding techniques using imported resin-coated sand, none of them have succeeded to make this a commercial proposition. On the other hand, no reports at all have been received of anyone attempting to carry out the lost-wax process. The programmes at MAS were thus the first serious attempts to carry out these processes with adequate technical back-up and using locally available materials. During his first two

visits in October 1978 and October 1979, Mr. Caton gave instruction on shell moulding and lost-wax process techniques and initiated tests to evaluate binders for the latter. However it was not possible to take these experiments further until MAS had moved to the new laboratories. Work on these processes was therefore re-established by Dr. Selcuk during his service in April 1980. Wax patterns were prepared from locally available waxes but the preparation of moulds was prevented by the lack of suitable refractories. However, full instructions on mould preparation have been given to MAS personnel and during their training in UK , Mr. Yasir Abu Bakr and Mr. M. Arshad Virk gained practical experience in the investment casting foundry of Rolls Royce Motors Limited. These factors combine to put MAS in a position to continue the work as soon as suitable refractory powders become available. Work on shell moulding continued at MAS on a small scale throughout the programme following Mr. Caton's first visit when the selection tests for shell moulding sands were taught to MAS personnel. However, larger scale tests could not be carried out until the closing stages of the programme. Thus, during his third and final period of Project Area service in November/December 1980, Mr. Caton installed and commissioned the "Cormatic' shell core making machine and instructed MAS personnel on the preparation of resin coated sand using selected local silica sand and imported powdered resins. The operation of the "Cormatic' machine was demonstrated to MAS personnel using the sand prepared at MAS and they were given full instruction in its operation to enable them to continue a programme of evaluating further local materials. (See Reports R795/1, R795/3, R795/5, R795/8).

3.1.4 Materials selection/Techno-economic evaluation

This one heading, which is fairly general in its coverage, in fact contains two clearly separate activities viz:

1. Advice on selection of foundry materials, techniques, etc.

2. Techno-economic evaluation of projects

Training of the counterpart personnel in these areas was given as appropriate during instruction on more specific topics. For example, great attention was given to the correct grades of sand to be used for shell moulding, similarly for CO_2/silicate moulding etc. Again, the correct choice of charge make-up for S.G. iron production

was given great importance. Similar emphasis on the correct choice of moulding and melting techniques was given to the production of cast rolls. This was therefore a theme which ran through all the various subjects which were taught to the MAS personnel during the programme.

The techno-economic evaluation of projects was again generally handled along with each individual subject. It was pointed out to the counterpart personnel that there are often several different methods which can be used to give the desired end product. The method which is chosen has to be arrived at by considering such items as, cost of materials, cost of equipment, number of parts to be made, etc., but perhaps of greatest importance in Pakistan, the availability of both materials and equipment. There seem to be two schools of thought in Pakistan; the first is based on the traditional way of life summed up in their expression "Old is Gold" which says that methods handed down from father to son must be adhered to; the second is the wind of change that says everything old must be wrong and only the most modern methods and equipment should be used. The members of the Fulmer Team were careful to make the MAS staff aware of the existence of these philosophies and instructed them to respect both but carefully consider the merits of each for each separate project they wished to appraise.

3.1.5 Technical advice to foundries etc.

As in the first phase of the MAS project, many of the enquiries from local metallurgical enterprises, which arrived at MAS during the Project Area service of team members, were referred to the Fulmer personnel. Advice was given both at the MAS laboratories and more often at the works premises where more detailed information could be obtained and demonstrations carried out when necessary. In Phase II however, the counterpart personnel were encouraged to handle the enquiries themselves to a great extent, using the visiting expert in support. In this way they gained the confidence needed to become effective after the Project Area programme expired. The Fulmer personnel laid great emphasis on the need for obtaining the correct information which often could only be obtained by a works visit. The MAS personnel were warned not to accept the 'story' given to

them by the enquirer without asking searching questions to establish whether they were being presented with the true problem. It is quite common for an enquirer to ask for advice on the wrong subject because he has not understood his own problems. MAS staff were told to ask tactful questions because they should not question the honesty of the enquirer, merely his understanding.

Typical enquiries handled during Phase II ranged from problems due to inadequate metal temperature control through selection of alloys for bronze bearings to complete works demonstrations on chill roll production. (Several detailed accounts will be found in Reports R795/1, R795/3, R795/5, R795/6, R795/8).

3.1.6. Quality control in foundries

The need for adequate quality control was emphasised throughout the programme. For each project (S.G. iron, roll making, shell moulding, etc.) the maintenance of consistent quality was given as much attention as the selection of the correct materials and procedures and relevant quality control tests explained for each subject. Many of the problems in the Pakistan foundry industry arise from a simple lack of understanding of the need for quality control. Often the 'buck' is passed and the phrase, "I have to use what I can get in the market" is a familiar cry from the heart. However, there should be nothing to stop the founder from checking what he gets from the market and taking suitable steps to modify it or use something else to compensate if necessary. A good example is found in the use of local sodium silicate solution for CO_2/silicate mould production. Observing a 'mountain' of castings with rock-hard cores which were proving almost impossible to knock out, the founder was asked how much silicate he was using. His excuse for using 9% (2 to 4% is normal) was that it came from the market and varied in quality. However, he was taking no steps to check its viscosity and modify it if necessary, nor to seek consistent supplies. (This topic is given greater treatment in Reports R795/6 and R795/8).

3.1.7. Seminars

A number of Seminars and Lectures together with practical demonstrations have been held throughout the Project Area service programme. Topics covered ranged from basic iron foundry practice through S.G. Iron and roll making to shell moulding and lost-wax process. Seminars were also given on quality control and NDT testing techniques.

A full list is given in Appendix IV together with references to those Progress Reports which contain further details of each seminar.

3.1.8. Product mix

During Phase I of the MAS project Mr. D.G.S. Davies prepared a comprehensive report on 'Pakistan Steel Mills'. He was requested to carry out a similar exercise on steel rolling in the State Engineering Corporation. This was carried out in December 1979. The melting and rolling capacity was surveyed and compared with the estimated demands for rolled products again obtained from a survey. Recommendations were given for improving the productivity and profitability of the State Engineering Corporation. (See Report R795/4).

3.1.9. Project services

Mr. Davies also made a study of the operation of the MAS laboratories during his visit in December 1979. A report was prepared which suggested an organisation and administration structure which could prove beneficial to the operational efficiency of MAS. For comparison, information was given relating to a similar laboratory in the UK. A section was also devoted to advice to MAS staff to enable them to improve the effectiveness of MAS in helping the Pakistan metallurgical industry. (See Report R795/4).

3.1.10 Analytical and test instruments

MAS personnel were given instruction in the use of the instruments for chemical analysis, including atomic absorption spectrophotometry and carbon/sulphur determination by Mr. D. Nicholas during April 1980. Instruction and demonstrations in the use of NDT techniques including X-radiography and ultrasonic testing was given by Mr. R.L. Crocker. During his Project Area service in October 1980 he also instructed in the use of mechanical testing equipment. Dr. T.J. Veasey instructed MAS personnel in the use of X-ray crystallography and thermal analysis instruments during December 1980. (See Reports R795/5, R795/7, R795/8).

3.2. Backstopping (Home Office Support Services)

A considerable degree of confusion seems to have arisen at MAS over the extent of the services to be given by Fulmer under

the heading of "Backstopping". No doubt this may have stemmed from the high level of interest in MAS's activities and concern for its smooth running shown by Fulmer personnel during Phase I, and which has continued though Phase II. This prompted MAS to make many requests of Fulmer to supply books, charts, materials, investigations, journals etc. during the periods in which no Fulmer personnel were present in the Project Area. These services are clearly outside the provisions of paragraph 2.02 c) which defines "Home Office Support Services" as provision of services and facilities to support staff members serving in the Project Area. Despite these limitations to Fulmer's obligations, the requests were met wherever possible in order to assist MAS in its development and cement the close working relationship which has existed between Fulmer and MAS throughout the Project. During the middle of 1980 however many demands were made on Fulmer's services which were not possible to meet at that time. In addition, it does not appear to have been appreciated by MAS, that in order for them to gain the maximum benefit from the Project Area service programme a considerable degree of preparation was needed to ensure that:-

1. the visiting experts were available at a suitable time,
2. the equipment to be used at MAS was functional, and
3. materials were available for the experts to use.

In most UNIDO Projects, a single 'Project Officer' or 'Technical Adviser' spends 1 to 3 years or more in the Project Area and there is time available to obtain materials and commission equipment. In this Fulmer Contract however, most of the individual members of the team of experts spent only 1 month in the Project Area. It was therefore absolutely essential that materials and equipment were 'to hand' to avoid wasting valuable time. Another factor was that since these were only short periods they could not constitute the main salary-earning activities of the experts during the year. It was therefore necessary to find suitable breaks during the experts' work schedules during which they could make themselves available for service at MAS. This does not imply in any way the experts were at all lacking in their dedication to giving their best services to MAS, merely that UNIDO should appreciate the limitations placed on the experts'

availability. Indeed, in most cases, the visiting experts spent many additional hours in the UK obtaining specialised materials and background information to enable them to match their Project Area service work to the specific needs of MAS.

The burden of coordinating the Project Area programme naturally fell upon the Fulmer Team Leader and occupied his services at the home office for considerable periods of time throughout the operation of the Contract. The justification for spending this amount of time in this way has been clearly demonstrated by the agreed success of the MAS Project which must, to a considerable extent, have been due to Fulmer's involvement. These sentiments have, in fact, been expressed to Fulmer both by MAS and UNIDO personnel.

3.3 Training

Of the total training period provided for in this contract, only three months of training had been taken up by the time of the expiry in December 1980. Mr. M. Mansoor Ali
Chief Chemist, visited Fulmer between August and November 1979 and received training in chemical analysis by both classical wet methods and instrumental methods including atomic absorption spectrophotometry, X-ray fluorescence and ultra-violet spectrophotometry. He was also given an introduction to mechanical testing and ultrasonic testing to prepare him for Mr. Crocker's visit to the Project Area which was to follow later.

MAS has submitted applications to the Pakistan Government for Mr. Zubair Malik and Mr. Iftikhar Ali to take up the balance of the training programme. However, delays have occurred in Pakistan which have prevented these trainees from visiting Fulmer before the expiry of the Contract on 31st December 1980.

In addition to these members of MAS staff, Fulmer also accepted Mr. Izhar Qureshi for six weeks' training on thermal analysis. This took place immediately prior to the commencement of the first period of Project Area service by Mr, Caton in 1978.

4. ACHIEVEMENT OF OBJECTIVES

The broad objectives of providing technical assistance to the Pakistan Metals Advisory Service have been successfully achieved. The assistance, which took a number of different forms, will now enable MAS to move forward under its own initiative.

- All the apparatus and equipment supplied to MAS by UNIDO has been demonstrated (after commissioning where necessary).
- MAS personnel have been instructed in the use of the apparatus and equipment.
- Instruction has been given on analysis, testing and quality control techniques.
- Instruction has been given on selection of materials and techniques for moulding, melting and casting.
- New foundry techniques have been demonstrated at MAS and on the shop floor.
- Technical advice and assistance has been given to local metallurgical industries and MAS personnel who were instructed how to carry out such investigations.
- Surveys have been carried out and advice given to improve the efficiency of rolling mills.
- Advice has been given on the organisation and administration of MAS.
- Seminars have been held to give instruction to a wider audience.

Individual areas of achievements during Phase II are summarised as follows, relevant Progress Reports are indicated at the end of each paragraph:-

1. The MAS sand testing laboratory has been set up and instruction given on the evaluation of bentonites by chemical, X-ray diffraction and thermal analysis techniques. This will enable MAS to widen the scope of the programme of evaluating local foundry sands and binders initiated in Phase I. (Reports R795/5, R795/8).

2. The production of nodular (S.G.) cast iron has been demonstrated both at MAS using the Radyne induction furnace and also on the shop floor at Ittefaq Foundries using their mains frequency induction furnace. MAS personnel were trained in the techniques involved and will be able to continue a programme of introducing S.G. iron into a larger number of Pakistan foundries. (Reports R795/6, R795/8).

3. Precision casting techniques were demonstrated to MAS staff. For shell moulding, instruction was given in the selection and resin coating of suitable sands and in the use of the Cormatic shell core making machine. For the lost-wax process, the MAS staff were given instruction in the selection of pattern waxes and the preparation of binder solutions. In each case, sufficient instruction was given to enable the counterpart staff to continue their own programmes to evaluate the use of local materials for these processes. (Reports R795/1, R795/3, R795/5, R795/8).

4. As well as advice and instruction on general foundry techniques, two specific areas were identified as being of particular importance in Pakistan viz:- ingot moulds, and rolls. Instruction and demonstration of production techniques were carried out at MAS and on the shop floor at large foundries such as H.F.F., Taxila and Ittefaq Foundries, Lahore. (Reports R795/6, R795/8).

5. Technical advice was given to a number of metallurgical enterprises in Lahore, Karachi, Rawalpindi etc. both at MAS and by shop floor visits and demonstrations. (Reports R795/1, R795/3, R795/5, R795/6 R795/8).

6. The need for adequate quality control was stressed to MAS personnel and to the industrial enterprises encountered during the programme. Simple shop floor tests, such as chill depth etc. were demonstrated to encourage the adoption of a quality-conscious attitude. (Reports R795/1, R795/3, R795/5, R795/6, R795/8).

7. A number of Seminars were held. Subjects covered included binders and moulding methods, precision casting, S.G. iron production, the metallurgy of cast iron, foundry techniques and NDT techniques. These were attended by MAS staff and a

number of industrial delegates from all over Pakistan. (Reports R795/1, R795/3, R795/5, R795/6, R795/7, R795/8).

8. A report was prepared on the steel rolling activities of the State Engineering Corporation and recommendations given for ways to improve its efficiency and profitability. (Report R795/4).

9. The organisation of MAS was studied and a report prepared outlining an approach to enhance its efficiency and effectiveness in assisting the Pakistan metallurgical industry. (Report R795/4).

10. The MAS staff were trained in the use of the analytical and test instruments including, atomic absorption spectrophotometry, X-ray diffraction, X-radiography, thermal analysis, mechanical testing and ultrasonic testing. (Reports R795/5, R795/7, R795/8).

11. Mr. Mansoor Ali received three months' training at Fulmer in wet and instrumental methods of chemical analysis. (Report R795/2).

5. CONCLUSIONS.

A programme of technical assistance to the Metals Advisory Service (MAS) in Lahore, Pakistan has now been successfully concluded. Whilst Fulmer Research Institute has been involved in this UNIDO project from its inception in 1975, this report describes Fulmer's rôle in Activity 2 of Phase II which extended from September 1978 to December 1980.

Seven Fulmer personnel provided a total of twelve months of Project Area service based in Lahore and gave instruction and training on a number of topics. These were broadly in three areas:-

- Foundry techniques
- Analytical and test techniques
- Techno-economic surveys

The MAS staff have now received training in the use of all the equipment supplied to them by UNIDO and instruction was given on specialised test techniques.

Training was given in the selection and preparation of refractories and binders for mould making and in melting and casting techniques.

New techniques have been demonstrated at laboratory and shop floor levels and MAS personnel instructed in the techniques involved. Topics included S.G. iron production, roll making, shell moulding and investment casting.

The importance of quality control was emphasised during the training and also at seminars and during works visits when advice and assistance was given to local metallurgical enterprises.

Advice was given on methods for improving the productivity of the state steel rolling activities and a document prepared providing advice on the organisation and administration of MAS.

Part of the training of MAS staff takes the form of fellowships to send them to the UK to spend some time at Fulmer Research Institute. Three members of MAS staff were selected to receive the training allocated in Phase II but, due to delays in Pakistan only Mr. M. Monsoor Ali

Senior Chemist, has so far received three months' training at Fulmer. The training of Mr. Zubair Malik, Junior Chemist, and Mr. Iftikhar Ali, Test Engineer, remained outstanding at the end of the Contract on 31st December 1980. However, an additional member of MAS staff, Mr. Izhar Qureshi, was also accepted by Fulmer for training on thermal analysis.

Throughout the Project Area service programme, great attention was placed upon the MAS personnel carrying out the tasks for themselves under the supervision of the visiting Fulmer experts to enable the MAS operators to gain confidence and proficiency which would carry them through after the outside help had left. The success of MAS will largely depend on the enthusiasm of its staff in practising the training given during this contract and seeking to expand their skills by applying the knowledge gained so far to a wider range of applications. It was clear to the Fulmer personnel that the future of MAS will be rather unpredictable in this respect. Whilst some MAS personnel showed great willingness to accept training and to apply it to their local needs as well as the ability to make good use of their training, there were others who showed a lack of enthusiasm or ability and in some cases an unwillingness to accept the views of others. The most disturbing feature was that this behaviour was shown by a Senior Engineer (Dr. Ikramul Haq) whose actions were disrupting the work of other MAS personnel and undermining the authority of the management. The Fulmer specialists were also alarmed by the high rate of absenteeism among MAS staff during the closing stages of the programme.

It is natural that in a situation where there is no strong metallurgical history, suitably experienced personnel could not be found for the senior positions. With its relatively inexperienced staff, progress at MAS will tend to be slow at first but gradually gain momentum as expertise is built up. MAS must therefore be careful to be neither over-optimistic about its abilitues, nor pessimistic about its range of knowledge. There is plenty of scope for improving the quality and hence the productivity and profitability of Pakistan foundries and MAS now has the staff and facilities to carry this out. Given the correct leadership and enthusiasm from its staff, MAS can provide the much needed service to be metallurgical industries in Pakistan.

It was suggested to MAS that a good way to both provide a service to industry and gain further experience would be to carry out a number of simple survey and research programmes. One example is foundry sands and binders. Whilst a large number of sands have already been examined, these are not being commercially explcited. MAS would do the foundry industry a great service if they could investigate the reasons why this has not happened and make recommendations and suggestions for plant and facilities. Similarly, the ground-work on the preparation of shell moulds and investment casting moulds has been started at MAS. They could now carry out more extensive programmes to examine the supply and use of local materials and investigate the best conditions for their use.

There is a tendency at MAS to sit and wait for things to happen. More initiative needs to be taken to start programmes of their own rather than merely deal with isolated enquiries. It would be helpful if UNIDO could remain associated with MAS by involvement in such special projects which would bring visiting experts into contact with the MAS personnel on further occasions.

To summarise:-

1. Fulmer has successfully completed the Project Area programme.
2. All the MAS equipment and instruments have been demonstrated.
3. MAS staff have been trained in the use of the equipment.
4. MAS staff have been trained in new foundry techniques and quality control methods for these and existing techniques.
5. The training programme at Fulmer's home laboratories could not be completed by December 1980 owing to delays in Pakistan.
6. The basis for a useful metallurgical advice centre has been established at MAS.
7. MAS now has the opportunity to assist the development of Pakistan's metallurgical industry by providing advice on foundry quality control, materials selection and analytical and test-house facilities.
8. Special projects, such as surveys of local materials, investigations of the use of local materials etc. should

be carried out to gain further knowledge and expertise.

9. A strong leadership must be shown by the MAS management to suppress disruptive elements emerging amongst the staff and encourage those whose enthusiasm is being undermined. Without sufficient action at an early date the benefits from UNIDO's aid programme will be lost.

6. ACKNOWLEDGEMENTS

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PDC/LAT
March 1981.

APPENDIX I

List of Progress Reports

R795/1, November 1978	:	First Monthly Progress Report, 1st October 1978 to 1st November 1978.
R795/2/September 1979	:	Second Progress Report, November 1978 to September 1979.
R795/3/November 1979	:	Third Progress Report, October 1979.
R795/4/April 1980	:	Fourth Progress Report, November 1979 to March 1980.
R795/5/June 1980	:	Fifth Progress Report April 1980.
R795/6/July 1980	:	Sixth Progress Report, May - June 1980.
R795/7/December 1980	:	Seventh Progress Report, July - November 1980
R795/8/December 1980	:	Eighth Progress Report, November - December 1980.

APPENDIX II

List of Appendices to Progress Reports

Report No.	Appendix No.	Title
R795/1	I	Selection of sands for shell moulding
	II	Re-appraisal of certain Pakistan sands for shell moulding.
	III	Casting of brass bush at Attock Oil Co.
R795/3	I	Project programme
	II	Counterpart training programme
	III	S.G. iron production
	IV	Investment casting slurries
	V	Cooling system for Radyne furnace
	VI	Lecture to Engineering Univeristy, Lahore.
R795/4	I	Steel re-rolling in the State Engineering Corporation.
	II	Organisation and administration of MAS.
R795/5	I	Project Area report by D. Nicholas.
	II	Visits to Chenab Engineering Works and Islam Industries.
	III	Visit to Messrs. Elektromolt.
	IV	Visit to Ghulam Mohi Ud Din and Sons
	V	Visits to Ittefaq Foundries.
	VI	Visits to Northern Foundries.
	VII	Visit to PECO, Badami Bagh Works.
	VIII	Vist to PECO, Kot Lakhpat Works.
	IX	Visit to Rastgar Industries.

APPENDIX II (Continued).

R795/6	X	The divided blast cupola.
	XI	Report on foundry coke.
	XII	Iron roll making.
	XIII	Code of practice for ingot mould manufacture.
	XIV	Code of practice for steelworks practice.
	XV	Compacted graphite for ingot moulds.
	XVI	The porous plug ladle.
	XVII	S.G. iron production.
	XVIII	Graphite-free layer on cast iron.
R795/7	I	Project Area Report by R.L. Crocker
R795/8	I	Project Area Report by R. Lee
	II	Project Area Report by T.J. Veasey.
	III	Papers given at 'Seminar on Investment Casting', December 1980.
	IV	Special Report on sand moulding.

APPENDIX III

PROJECT AREA SERVICE

List of personnel engaged in the Project Area programme with periods of service and subjects covered:

P.D. Caton : 3 months (Oct 1978, Oct. 1979, Dec. 1980): Team Leader and precision casting.

D.G.S. Davies : 1 month (Nov/Dec. 1979): Product mix, project evaluation.

D. Nicholas : 1¼ months (March - May 1980): Chemical analysis

E. Selcuk : ¼ month (April 1980) : Precision casting, foundry sands.

R. Lee : 4¼ months (March - May, Oct - Dec 1980) : S.G. iron, roll making, foundry quality.

R.L. Crocker : ¼ month (Oct/Nov 1980) : Mechanical testing, NDT.

T.J. Veasey : 1 month (Dec. 1980) : X-ray diffraction, thermal analysis.

APPENDIX IV

SEMINARS AND LECTURES

Date	Title	Progress Report reference
October 1978	Precision Casting Techniques	R795/1
October 1979	Engineering Applications of Non-Ferrous Metals*	R795/3
April 1980	The Metallurgy of Cast Iron	R795/5
"	The Importance of Sand Control in the Foundry	"
April/May 1980	Iron Foundry Practice	R795/6
"	S.G. Iron Production	"
"	Cast Iron Rolls	"
"	Ingot Mould Production and Use	"
October 1980	The Rôle and Practice of NDT in Industry	R795/7
December 1980	Investment Casting Techniques	R795/8
"	Binders for the Foundry	"

* At Engineering University, Lahore, all others held at MAS.

APPENDIX V

KEY TO PROJECT AREA SERVICE REPORTS

Author	Progress Report Number(s)
P.D. Caton	R795/1/November 1978
	R795/3/November 1979
	R795/8/December 1980
D.G.S. Davies	R795/4/April 1980
D. Nicholas	R795/5/June 1980
E. Selcuk	R795/5/June 1980
R. Lee	R795/6/July 1980
	R795/8/December 1980
R.L. Crocker	R795/7/December 1980
T.J. Veasey	R795/8/December 1980