4．技術セミナーの概要

（1）技術セミナー実施状況

国名	日時	場所	主な参加者
マレイシア	3月5日（水） 10：00－17：30 （写真SM-1,2）	Holiday Inn Shah Alam Kayangan の１室	西牧JICAマレイシア所長、 佐藤同所次長 飛田氏、渡辺氏 Follow Up Team 4名 帰国研修員10名 その他関係者18名 セミナー参加者リストSM-2
スリ・ランカ	3月12日（水） 13：00-17：30 （写真SM-4,5）	Colombo Hilton の１室	日本大使館新沼2等書記官 加納JICAスリランカ所長、 藤原同事務所職員 H．N．Perera氏 Frollow Up Team 4名 コロンボ大学学長 大蔵省対外資金局長 帰国研修員 8名 その他関係者 40名 セミナー参加者リストSM-4

（1）－1マレイシアでのセミナー概要

<開会>

SIRIMの金属加工技術センターのGeneral ManagerであるMr. A. Halin Ab. Rahman氏の挨拶およびFollow - Upチームの紹介がなされた。続いて、西牧JICAマレイシア事務所所長より挨拶がなされた。

・すでに、600名の研修員を人材育成のため日本に送っている。
・溶接コースも16名が研修を終え帰国してそれぞれ活躍している.
・本セミナーは最近の溶接技術に関する知識や情報を伝えるために開催するものである。
・なぜなら、溶接製品の品質は非常に重要であり、我々とマレイシアの人々との間でこれらの重要な知識を分け合うことはとても意義があるからである。

<講演I>

「アーク溶接および特殊溶接における最近の発展傾向」
講師：沓名宗春（名古屋大学工学部助教授）

・1974年より名古屋国際研修センターでの溶接技術集団研修コースが益本先生らの尽力で始められ24年目となる。今回はこのコースのFollow - Upチームに参加し、帰国研修員に再会できた事は大変嬉しいことをまず伝えた。
・つぎの資料について順にOHPで最近の溶接技術について紹介がなされた。
資料「日本におけるアーク溶接ロボットの最近の傾向」
資料「日本におけるコンピュータ支援溶接（CAW）」
資料「先進工業化諸国でのレーザ応用技術の進歩」
資料「鋼およびアルミニウム合金のレーザ溶接における冶金学的問題点」
・つぎに、溶接の世界的発展傾向というよりも「生産技術やものづくりの発展」について、5000年前から現在までの技術移転の方向が北極を軸として右まわりに進展してきた歴史が紹介されるとともに、21世紀にはマレイシアなどのASEAN諸国に技術移転が進むことが必然的であることが説明された。
・資料「JICAの溶接技術研修コースの現状」について説明がなされた。

＜講演2＞
「マレイシアにおける溶接技術の現状」
講師：Mr. Ab. Ghalib H. X. Tham氏（SIRIMの金属加工技術センター主任研究員）

・資料「マレイシアにおける溶接技術の発展」に基づき，1960 - 1975，1976-1990，1991-2000の3つの発展期に分けて詳しく紹介された。それによるとつぎのようにマレイシアでは発展してきた。
［1960－1975期］・・・工業化の開始
訓練を受けていない溶接工が主で、ガス溶接を主としていた。被覆アーク溶接、スポット溶接も利用されるようになる。溶接機をLincoln社がマレイシアで生産開始した。Tham氏自身はスエーデン人の溶接技師に5Gや6Gの溶接を習った。このころより、政府により職業訓練校が開設された。そして、その中の優秀な者は溶接技師（Welding Instractor／Technician）になった。溶接製品の品質管理にはBSやASMEが適用された。
［1976－1990期］・・・技術の移転・普及、拡大
訓練校および訓練された溶接工が増加し、ガス溶接および被覆アーク溶接が主に適用されるようになった。一部は自動溶接も取り入れられるようになった。インバータ電源も導入され始めた。溶接製品の品質管理にはBSやASMEの他にDINやJISも適用されるようになった。この期の主な進歩は次の点である。
(1)技術移転の成功

(2)技術相談の進歩
(3)溶接の問題点の解決
［1991－2000期］・・・発展期
・スポット溶接、プロジェクション溶接、自動溶接も多く利用されるようになり、溶接ロボットも適用されるようになった。
・1990年には溶接ロボットが5～6台であったが、1996年には300～400台に増加した。ある家具を生産する企業では20人の従業員に対して、20台の溶接ロボットを利用している。ただし、溶接技術の研究・開発の面では非常に遅れており、今後日本や欧米からの導入だけでなく、自国での研究を進める必要がある。
・品質保証にISO9000番が導入され、1990年に50社、1996年には750社がISOの品質保証制度を採用している。
・溶接工の賃金も1996年には150Mドル（約7,500円／日）と高くなったので、機械化や自動化を進めなければいけない。
—将来の展望—
マレイシアから第3国への投資が進むと思われるが、溶接技術も首都や主要都市から地方に拡大していくだろう。国の発展に最も重要なのは、以下の３点である。
(1)平和であること。戦争はすべてを失ってしまうので、平和な環境をつくる必要がある。
(2)油やガスを保存、確保すること。
(3)工業化の促進を続行すること。

＜講演3＞
講師：野村博一氏（日本鋼管工事専務取締役）
つぎの3つのテーマの講演がなされた。
（1）「ISO9000番に関するISO溶接関連規格の紹介」
資料「ISO－3834－Part 1：溶接品質の選択と適用」
資料「ISO－3834－Part 2：総合的な品質要求事項」
資料「ISO－3834－Part 3：標準的な品質要求事項」
資料「ISO－3834－Part 4：初歩的な品質要求事項」
資料「ISO－3834－Part 5：溶接要員、その業務と責任」
資料「ISO 9606－1：溶接技能者の検定試験」
について解説がなされた。
（2）「IIWの新制度による溶接要員の教育、訓練、認定システムに対する要求」
資料「溶接要員に対するIIWの認定制度」
資料「日本溶接協会によるIIWの認定制度への提言」
に基づき、詳しくIIWの溶接要員認定制度およびそれに対する日本の対応などが説明された。

・これらの教育・訓練の基本となるカリキュラムについて説明がなされ、現在日本の準備状況が説明された。

質問：
・移行期間は3年間であり、その時、JICAの研修生が過去に取得したWESの資格がどうなるか？…移行時には連絡がある。
・シンカポール溶接協会はこの制度への参加を検討しているが、マレイシアは溶接協会が現在存在せず、協会の設立についてDr. Samsudin氏はJICAの協力が得られるか質問した。同氏としては、できれば、CIASTや企業の協力で設立し、ASEAN諸国のリーダーとしてやりたいとの意向。それには今後、SIRIMがリーダーシップを取ってやるべきであろう。

(3)「溶接技術の国際的な傾向と市場」
資料「溶接技術の国際的な傾向と市場」
資料「造船における溶接の機械化および自動化の現状」
についても造船業を例にとり、溶接の機械化および自動化の具体策が紹介された。

＜プログラム＞
別添プログラム参照。
マレイシアでの公開技術セミナーはJICAとSIRIMの協同開催で行われ、フォロ－アップチームから２件、SIRIMの主任研究員から１件の講演が行われ、モデレーターはSIRIMの帰国研修員Dr. Samusdin Bani氏にお願いした。午前の部終了後、チームリーダー沓名助教授主催の昼食会が催され、帰国研修員との旧交を深めた。
閉会にあたって沓名助教授より出席者全員に受講証明書が手渡された。

（１）－２スリランカでのセミナー概要
＜開会＞
[加納JICAスリランカ事務所所長の開会の挨拶]
・JICAはスリランカ政府と日本政府間の協力としていろいろな形でスリランカの発展に努力してきた。
・本セミナーは最近の溶接技術に関する知識や情報を伝えるために開催するものである。マレイシアの専門家の人々にとって、これらの重要な知識が役立てば幸いである。
[沓名Follow - Upチーム団長の挨拶]
[Hr. Passaperuma大蔵省対外資金局次長の挨拶]

＜講演1＞
「アーク溶接および特殊溶接における最近の発展傾向」

講師：沓名宗春（名古屋大学工学部助教授）
内容はマレイシアでのセミナーと同様で、省略。

＜講演2＞
講師：野村博一氏（日本鋼管工事専務取締役）
つぎの3つのテーマの講演がなされた。
(1) 「ISO9000番に関するISO溶接関連規格の紹介」
(2) 「IIWの新制度による溶接要員の教育、訓練、認定システムに対する要求」
(3) 「溶接技術の国際的な傾向と市場」
内容はマレイシアでのセミナーと同様。

＜プログラム＞
別添プログラム参照。

（2）質問表集計結果（マレイシア／スリ・ランカ）

1) 興味を持った講演内容

- JICA溶接コースの研修、教育スキーム（2／0）
- コンピュータ支援溶接／ロボット溶接（1／2）
- レーザー溶接（6／11）
- 鋼及びアルミニウム合金の溶接、冶金（1／0）
- 最新の溶接技術、応用について（5／3）
- IIW資格認定制度の枠組み（5／4）
- ISO溶接規格（12／4）
- 溶接技術の国際的な傾向と市場（2／0）
- マレイシアにおける溶接技術の現状（1／—)

2) 溶接技術コースに希望する研修項目

- 溶接に関するエキスパートシステム、ソフトウェアの開発（1／0）
- IIWの認定するエンジニア、検査官コース（1／1）
- コンピュータ支援溶接／ロボット溶接（12／3）
- レーザー溶接（8／6）
- 最新の溶接技術、応用について（8／6）
- ISO溶接規格（1／0）
- 破壊、非破壊検査、品質管理（7／0）
- 基本的な溶接技術（1／0）
- 造船、船舶修理（0／1）
- 鋼及びアルミ合金の溶接、冶金（1／2）
- 職業訓練学校での研修、教育方法（0／1）

（複数回答有り）

5．研修効果とコース改善への提言

帰国研修員は帰国後、それぞれの立場で溶接技術に直接関連した業務を行っている研修生が多く、日本での研修の成果を業務の中て非常に有効に生かしている。かれらに研修の成果をどのくらい生かしているか質問して見るといずれも80%から100%と高い評価を得ている。ただし、日本の指導者から見ると、それぞれの国の工業化や溶接技術事情により、日本で教育した近代的な溶接技術が十分伝承されているわけではないことが今回の調査で明らかになった。たとえば、半自動溶接の施工技術やガスシールドアーク溶接の技術でさえ、国内にシールドカスのボンベを十分配給できるシステムが欠けているため、適用が非常に困難である。

マレイシアは比較的これらの近代的溶接技術を導入できる体勢が整ってきており、今後の技術発展は大きいと思われるが、スリ・ランカの場合にはまだまだ、近代的溶接技術を導入するには解決すべき問題が諸処あるので、まずは、近代的溶接技術を導入し、問題点を示すようなセンターをJICAの支援で設立し、国内の溶接関係者との連絡会（スリ・ランカ溶接協会のような）を通じて、国内の大，小の企業の溶接問題を解決していくことが、着実な近代化への道と思われる。

マレイシアの溶接事情で注目されるのは「近代的溶接技術の研究・開発」に着手し、製品の国産化への努力を進めようとする動きであり、これにはセミナーや講師の派遣により、これらに適切に応対し、新しい情報をマレイシアに提供するシステムを有効に構築することが今後のJICAの協力として重要のように思われる。

よって、当溶接技術研修コース改善への提言としては、つきのような点があげられる。

(1) 溶接技能の実習には近代的な溶接法の修得にもっと時間をさく。
(2) 近代的な溶接法（半自動溶接、各種ガスシールドアーク溶接など）に用いられる溶接機器およびシステムについても十分実習する。
(3) 世界溶接会議（IIW）の溶接要員の認定制度におけるWelding Engineerレベルの教育内容は最低確保する。
(4) グループによる企業内実習については各国の溶接事情も考慮して実施する。
(5) 国別紹介の際には国の溶接事情をもう少し詳しく紹介するように指導する。

6．添付資料

(1) 現地報告書

(2) 帰国研究員リスト

(3) 技術セミナーの講演資料

(4) 各種質問票

(5) 持ち帰り資料

(1) 現地報告書

April 15, 1997

Dear Sir / Madame;

Team Leader
Muneharu KUTSUNA

It is my great pleasure to submit the Summary Report of the Follow-Up Team for the training course in welding technology.

The mission, which was dispatched by Japan International Cooperation Agency as a part of its technical follow-up program, and consists of 4 members as mentioned in the report, stayed in Malaysia from 3 to 8 March, 1997. Through the visit of this time, we could obtain many valuable comments and suggestions about the course from the competent authorities concerned and also from the ex-participants and other people around them. We are quite sure that the information we acquired should be greatly useful for the purpose of improving this course and also the entire technical cooperation program of JICA.

Finally I would like to express my heartiest appreciation for your warm hospitality and kind cooperation extended to us during our stay in your country.

M. Kutsuna

SUMMARY REPORT
BY
THE FOLLOW-UP TEAM
OF THE GROUP TRAINING COURSE
ON
WELDING TECHNOLOGY

MALAYSIA

INDEX

1. OBJECTIVES

The objectives of this follow-up team are as follows;

(1) To evaluate the course by conducting the research on how much the result of the training is applied and how it affects to the field concerned in respective countries.
(2) To research the overall of this training field in the countries the team will visit, thus to seize the problems and needs in respective countries.
(3) To improve the JICA's future training program on welding technology.

2. PERIOD

From 3 March to 8 March, 1997 (Malaysia)

3. MEMBERS

Team Leader	Dr. Muneharu KUTSUNA Associate Professor, Dept. of Material Processing Eng., School of Engineering, Nagoya University
Technical Adviser	Dr. Hirokazu NOMURA Senior Managing Director, Nippon Kokan Koji K.K.
Training Auditor	Mr. Hajime YANAGIBASHI Deputy Director, Nagoya International Training Centre, Japan International Cooperation Agency
Coordinator	Mr. Mikiya SAITO Training Officer, Nagoya International Training Centre, Japan International Cooperation Agency

4. SCHEDULE OF THE FOLLOW-UP TEAM (MALAYSIA)

Mar. 3 (Mon)	Arrival
Mar. 4 (Tue)	JICA Malaysia Office Courtesy Call on Embassy of Japan Medan MARA (Majlis Amanah Rakyat) Public Service Department, The Prime Minister's Dept.
Mar. 5 (Wed)	Metal Production Technology Centre, SIRIM Follow-up Seminar
Mar. 6 (Thu)	Move to Johor Bahru Universiti Teknologi Malaysia IKM, Johor Bahru Malaysia Shipyard and Engineering Sdn. Bhd.
Mar. 7 (Fri)	Move to Kuala Lumpur JICA Malaysia Office Construction site of K.L. International Airport Berhad
Mar. 8 (Sat)	Departure for Sri Lanka

5. INSTITUTIONS IN MALAYSIA THE TEAM VISITED

(1) Public Service Department, The Prime Minister's Dept.
(2) Metal Production Technology Centre, SIRIM
(3) Medan MARA (Majlis Amanah Rakyat)
(4) IKM, Johor Bahru
(5) Universiti Teknologi Malaysia
(6) Malaysia Shipyard and Engineering Sdn. Bhd.
(7) K.L. International Airport Berhad

6. IMPRESSION OF THE TEAM

The follow-up team visited 1 ministry, 3 governmental organizations, 2 educational facilities and 1 private company. Owing to good arrangements of JICA Malaysia Office, we could meet many of ex-participants of this training course, who are mainly in the field of welding or other related field.

-Evaluation of the JICA Welding Technology Course by the ex-participants

All ex-participants expressed their appreciation to have had an opportunity to participate in the JICA training course, and stressed that the knowledge and experience they obtained were very useful and helpful for their work. Welding instructors could transferred the knowledge to the students on their class, and for engineers of national research centre, it was helpful to provide technical training and consultantation service for industry field. All of the ex-participants requested continuous support of JICA, by providing new information of welding technology.

-Evaluation of the JICA Welding Technology Course by the Visited organizations

Many organizations the team visited recognized the necessity of modernization of welding field, and highly evaluated the achievement of the training course. New information and equipments are required in vocational schools and research centre. It stands to reason that SIRIM wants to have new facilities, such as Laser processing and Electron beam welding equipments, as one of the most advanced research institutes in Malaysia.

-Impression

Gas, SMAW (manual), SAW, CO_2, MIG /MAG and TIG are in common use in most companies in Malaysia. However, most welding processes, other than Gas and Manual welding, are lacking for facilities and instructors. Education on welding is only for welders, the one for engineers is quite few. Research and development on welding technology is done at some institutes (SIRIM, universities), which don't have enough researchers and facilities. Robot welding, special metal/alloy welding and other high-technology welding aren't in common in Malaysia yet.

On the other hand, Malaysia is ready for applying modern welding technology now. Then, it must be necessary to establish the association for the advancement of welding technology. In Japan, academic society and association played an important role in stimulating the exchanges between industry, academy and authorities. On setting up an association for welding in Malaysia, some cooperation from the Japan Welding Engineering Society would be available. Now, SIRIM is trying to set up Malaysian standardization, the Japan Welding Engineering Society can also provide some cooperation on it.

Advancement of welding technology will be found in near future in Malaysia, and Japan can provide many kinds of cooperation for it.

Finally, we would like to express heartfelt gratitude to all the respective authorities concerned, and our dear ex-participants for their kind cooperation, assistance and hospitality. We could not have carried out the work if it had not been for tremendous help rendered by those who are concerned.

Thank you very much.

April 15, 1997

Dear Sir / Madame;

Team Leader
Muneharu KUTSUNA

It is my great pleasure to submit the Summary Report of the Follow-Up Team for the training course in welding technology.
The mission, which was dispatched by Japan International Cooperation Agency as apart of its technical follow-up program, and consists of 4 members as mentioned in the report, stayed in Sri Lanka from 8 to 13 March, 1997. Through the visit of this time, we could obtain many valuable comments and suggestions about the course from the competent authorities concerned and also from the ex-participants and other people around them. We are quite sure that the information we acquired should be greatly useful for the purpose of improving this course and also the entire technical cooperation program of JICA.
Finally I would like to express my heartiest appreciation for your warm hospitality and kind cooperation extended to us during our stay in your country.

M. Kutsuna

SUMMARY REPORT
BY
THE FOLLOW-UP TEAM
OF THE GROUP TRAINING COURSE
ON
WELDING TECHNOLOGY

SRI LANKA

INDEX

1. OBJECTIVES

The objectives of this follow-up team are as follows;

(1) To evaluate the course by conducting the research on how much the result of the training is applied and how it affects to the field concerned in respective countries.
(2) To research the overall of this training field in the countries the team will visit, thus to seize the problems and needs in respective countries.
(3) To improve the JICA's future training program on welding technology.

2. PERIOD

From 8 March to 13 March, 1997 (Sri Lanka)

3. MEMBERS

Team Leader	Dr. Muneharu KUTSUNA Associate Professor, Dept. of Material Processing Eng., School of Engineering, Nagoya University
Technical Adviser	Dr. Hirokazu NOMURA Senior Managing Director, Nippon Kokan Koji K.K.
Training Auditor	Mr. Hajime YANAGIBASHI Deputy Director, Nagoya International Training Centre, Japan International Cooperation Agency
Coordinator	Mr. Mikiya SAITO Training Officer, Nagoya International Training Centre, Japan International Cooperation Agency

4. SCHEDULE OF THE FOLLOW-UP TEAM (SRI LANKA)

3/8 (Sat) Arrival

3/10 (Mon) Courtesy Call on Embassy of Japan
JICA Sri Lanka Office
Department of External Resources, Min. of Finance and Planning, Ethnic Affairs and National Integration
Min. of Industrial Development
Min. of Labour and Vocational Training

3/11 (Tue) Private Factories
(Alloy Fabricator International, Dynamic Technologies LTD.)
Industrial Development Board
Technical College RATMALANA
Automobile Engineering Training Institute
Colombo Dockyard LTD.

3/12 (Wed) Meeting with ex-participants
Follow-up seminar

3/13 (Thu) Departure from Sri Lanka

5. INSTITUTIONS IN SRI LANKA THE TEAM VISITED

(1) Department of External Resources,
Min. of Finance and Planning, Ethnic Affairs and National Integration
(2) Industrial Development Board, Min. of Industrial Development
(3) Department of Technical Education and Training,
Min. of Labour and Vocational Training
(4) Automobile Engineering Training Institute, NAITA
(5) Technical College, Ratmalana
(6) Alloy Fabricator International (Pte) Ltd.
(7) Dynamic Technologies (PVT) LTD.
(8) Colombo Dockyard Limited

6. IMPRESSION OF THE TEAM

The follow-up team visited 3 ministries, 3 governmental organizations and 3 private companies. Owing to good arrangements of JICA Sri Lanka Office, we could meet with many of 16 ex-participants of this training course, who are mainly in the field of welding or other related field.

-Evaluation of the JICA Welding Technology Course by the ex-participants

All ex-participants expressed their appreciation to have had an opportunity to participate in the JICA training course, and stressed that the knowledge and experience they obtained were very useful and helpful for their work. Welding instructors could transferred the knowledge to the students on their class, and for engineers of national factory and research centre, it was helpful to implement new facilities and technologies. All of the ex-participants requested continuous support of JICA, by providing new information of welding technology.

-Evaluation of the JICA Welding Technology Course by the Visited organizations

Many organizations the team visited recognized the necessity of modernization of welding field, and highly evaluated the achievement of the training course. Further, there is a request of setting up welding technology centre in Sri Lanka, which provides the knowledge and practice of modern welding technology.

-Impression

The main welding process in Sri Lanka's welding field is Gas welding and Shielded metal arc welding (manual). Gas shielded arc welding (MAG/MIG, TIG) is quite few in Sri Lanka which is the main process in Japan. To introduce new technology and develop nation industry, it must be needed to make it easier to access overseas new information, and train the welder and engineer who can handle modern welding process such as MAG, MIG and TIG. The proposals for it are as follows;
(1) Hold technical seminars regularly to introduce new information
(2) Set up Welding Centre (or Metal Production Technology Centre), Which provide education and practice on modern welding technology, such as Gas shielded metal arc welding
(3) The proposed centre is to have a role of "Introduction of technology", "Utilization of technology" and "Technology transfer"

Finally, we would like to express heartfelt gratitude to all the respective authorities concerned, and our dear ex-participants for their kind cooperation, assistance and hospitality. We could not have carried out the work if it had not been for tremendous help rendered by those who are concerned.

Thank you very much.

(2) 帰国研修員リスト

Welding Technology Course
The List of Participants from Malaysia

Welding Course started from 1974, it has accepted 216 overseas participants. There are 15 ex-participants from Malaysia as follows.

-NAME- (Fiscal Year)
(1) Date of Birth
(2) Educational Record
(3) Present Post
(4) Home Address

Mr. Jaafar Bin Rusmin (個1994)
(1) Jun. 23, 1965
(2) Sijil Pelajaran Vocational Malaysia
(3) Welding Technician, Faculty of Mechanical Engineering, Unversity Technology Malaysia マレイシア工科大学機械工学部 溶接技術者
(4) No. 17, JLN. ARA 13, TMN. Sri Pulai, 81110 Kangkar Pulai, Johor

Mr. ZAMIN Bin Mat Dain (1990)
(1) Sep. 19, 1952
(2) Industrial Training Institute (Teaching Technique Iin Welding Tech.)
(3) Vocational Instructor (Welding), MARA Vocational Institute
(4) Vocational Institute, Post Box 3271, 93764 Kuching, Sarawak

Mr. Mohd. RAZALI B. Sidek (1990)
(1) May 27, 1946
(2) Industrial Training Institute (Teaching Technique Iin Welding Tech.)
(3) 上級職業訓練指導員（溶接） マラ職業訓練学校
Senior Vocational Instructor (Welding), MARA Vocational Institute
(4) Block B21, Jalan SM 1E/3, Sri Manjong, 32000 Sitiawan, Perak

Mr. RADZUAN Bin Nong (1990)
(1) Jul. 31, 1956
(2) MARA Institute of Technology (Mechanical Engineering)
(3) Mechanical Engineerl, Public Work Dept., Negeri State Workshop
ネグリ州工場機械技師
(4) No.1199 Jalan Kedidi 7, TMN. Paroi Jaya, 70400 Serbmban N. Sembilan

Mr. Mohd. ALI Bin Shaik Dawood (1989)
(1) Apr. 27, 1955
(2) Western Washington Univ. (U.S.A.), Vocational Tech. Instructor
(3) Vocational Instructor (Welding), MARA Vocational Institute
(4) 287 Kg. Parit Tengah 26600 Pehan Pahang, West Malaysia

Mr. Jumadi Bin Giman JO (1988)

(1) Apr. 3, 1955
(2) Western Washington Univ. (Vocationa Teaching)
(3) Vocational Instructor (Welding Technology), MARA Vocational Institute
MARA職業訓練大学溶接技術指導教官
(4) 84, Rumah Murah, Peramu, Jaya 1Pekan, 26600 Pahang

Mr. PAUL Mohd. Yusof Bin Abdullah (1986)

(1) Jun. 28, 1950
(2) Welding Diploma, Associate Degree of Science in Teaching of Welding, Ferris State Collage (U.S.A.), Industrial Training Institute Kuala Lumpir
(3) Institute Kemahiran Mara (Mara Vocational Institute) マラ職業訓練大学教官
(4) Lot 66-B Jalan Perpaduah, Indian Settlement, Batu Gajah Perak 31000, West Malaysia

Mr. AHMAD Alias Awang Bin Salleh (1985)

(1) Dec. 12, 1947
(2) Industrial Training Institute in Kuala Lumpur
(3) Senior Instructor, Mara Vocational Institute マラ工科大学講師
(4) 727, Losong Haji Mat Shafie, Kuala Trengganu

Mr. SAARI Bin Zakaria (1983)

(1) Apr. 14, 1952
(2) Technical Teacher Training College (Welding &Sheet Metal)
技術教員養成大学（溶接・板金）
(3) Vocational Teacher, Vocational Secondary School 職業訓練高等学校教師
(4) B-695-A, Jalan Beserah, ALOR AKAR, Kuantan, Pahang

Mr. DAWOT Bin Hussin (個1982)

(1) Dec. 14, 1953
(2) Secondary School Institute Training Industry 中学校産業訓練所
(3) Technician Welding, MITEC, SIRIM
(4) SIRIM P.O. Box 35, Shah Alam, Selangor

Mr. Karunaneethi s/o ANNAMALAI (個1981)

(1) Oct. 5, 1953
(2) Brighton Polytechnic ブライトン工業学校（機械工学）
(3) Research Officer, SIRIM
(4) 34, Lorong Bungor Off Jalan Sami, Port Klang, Selangor

Mr. Abdul Ghalib H.K. THAM (個1980)

(1) Sep. 30, 1951
(2) マラヤ大学（機械工学）
(3) Research Officer, Metal Industries Technology Center (MITEC), Standards & Industrial Research Institute of Malaysia (SIRIM)
(4) c/o MITEC, SIRIM, P.O. Box 35, Shah Alam, Selangor

Mr. KHAMIS bin Ujang (1979)

(1) Oct. 7, 1947
(2) 産業訓練大（溶接）
(3) Instructor of Welding, Majlis Amanah Raaayat (MARA)
(4) No. 6214, Rumah Murah, Perbadanan Kemajuan Negeri Melaka, Kelemak, Alor, Gajah, Melaka

Mr. KHOLIL Bin Sulaiman (1977)

(1) Aug. 8, 1940
(2) オランダロッテルダム職訓センター
(3) Technical Teacher, Institute Kemahiran MARA
(4) No. 18 Lorong C3, Kampong Pandan, Kuala Lumpur

Mr. IDRIS Bin Mohamad (1976)

(1) Aug. 1, 1946
(2) 職業訓練大（溶接）
(3) Instructor, Industrial Training Institute, Kuala Lumpur
(4) 715-A, Sungei Dua, Penang

Welding Technology Course
The List of Participants from Sri Lanka

Welding Course started from 1974, it has accepted 216 overseas participants. There are 17 ex-participants from Sri Lanka as follows.

-NAME- (Fiscal Year)
(1) Date of Birth
(2) Educational Record
(3) Present Post
(4) Home Address

Mr. Geekiyanage Don Sisira KARUNARATNE (1996)
(1) Sep. 12, 1960
(2) モラツワ大学　機械生産工学専攻
Univ. of Moratuwa, National Diploma in Technology of Mechanical Production Eng.
(3) スリランカ工業開発局マーケティング課技術補佐
Technical Assistant, Marketing Div., Industrial Development Board of Sri Lanka
(4) 37A, Sunethradevi Rd., Kohuwala, Nugegoda, Sri Lanka

Mr. I. A. K. Karunathilaka PERERA (1992)
(1) Dec. 4, 1945
(2) 国立教員養成大学　職員訓練専攻
National Technical Teacher Training College
(3) 教育高等教育省　技術大学、機械加工分野上級指導員
（テクニシャンレベルの生徒に対する溶接、製造の理論、実習指導担当）
Senior Instructor in Metalwork, Technical Education Division, Secretary, Ministry of Education and Higher Education
(4) 16/42, Wijayapura, Pellenwatta, Pannipitiya, Sri Lanka

Mr. P. N. Kumarasiri DIAS (1991)
(1) Oct. 19, 1958
(2) モラツワ大学機械工学
Univ. of Moratuwa, Mechanical Eng.
(3) 自動車工学訓練研修所　部長、講師
Lecturer, Head of Division (Metal Eng. & Welding Tech.), Automobile Engineering Training Institute
(4) 120/6, Alakeshwara Rd., Etul Kotte, Kotte, Sri Lanka

Mr. Sudampe Edippilige SUMANASIRI (1989)
(1) Feb. 14, 1954
(2) Univ. of Sri Lanka (mechanical Eng.)
(3) 機械技師、セイロン製鉄所
Mechanical Engineer, Ceylon Steel Co.
(4) 5 Housing Scheme Ceylon Steel Co., Athurugiriya, Sri Lanka

Mr. K. S. W. Sirisena SANATH (1988)

(1) Feb. 16, 1954

(2) Univ. of Sri Lanka (mechanical Eng.)

(3) セイロン製鉄所保全部主任機械技師

Senior Mechanical Engineer, Ceylon Steel Co.

(4) 6 Housing Scheme Ceylon Steel Co., Athurugiriya, Sri Lanka

Mr. B. A. V. Jayawardene (1987)

(1) Jan. 5, 1944

(2) Kurunegala College (mechanical eng.)

(3) クリヤピチャ技術大学　上級講師

Senior Instructor, Technical College, Kuliyapitya

(4) No. 28, Udawalpola Rd., Kurunegala, Sri Lanka

Mr. Dayananda Chandana Jayaratne (1986)

(1) Jul. 22, 1949

(2) Univ. of sri Lanka, Electrial Eng.

Twickenham College of Technology, London

(3) 国立技術研究開発センター　研究技師

Research Engineer, National Engineering Research & Development (NERD),

Center of Sri Lanka Industrial Estate Ekala, Jaela

(4) No. 14, Galle Rd., Mount Lavinia, Sri Lanka

Mr. Teanuwera Arachige Wickramasinghe (1984)

(1) Aug. 14, 1950

(2) Univ. of Sri Lanka

(3) スリランカ国営エンジニアリング公社　プロジェクト部長

Project Manager, State Engineering Corporation of Sri Lanka,

130, W. A. D. Ramanayake, Mawatha, Colombo 2, Sri Lanka, Tel. 34943

(4) B 13-1-1, Maligawatte, Housing Scheme, Colombo 10, Sri Lanka

Mr. Kathira-vellupillai Sivananthan (1983)

(1) Jul. 7, 1950

(2) Univ. of Sri Lanka (Mechanical Eng.)

(3) コロナワ政府管理工場　工場次長

Assistant Works Manager, Government Factory, Kolonnawa, Wellampitiya,

Sri Lanka, Tel. 572351 or 572352

(4) "Siva Pathy" Vaddukoddi-West, Vaddukoddi, Sri Lanka

Mr. Wansapura Arachchige Peter (1980)

(1) Oct. 5, 1947

(2) Univ. of Sri Lanka (Mechanical Eng.)

(3) コロナワ政府管理工場　工場次長

Assistant Works Manager, Government Factory, Kolonnawa, Wellampitiya,

Sri Lanka, Tel. 572351 or 572352

(4) 211/7, Moratumulla, Moratuwa, Sri Lanka

Mr. Jegaratnam Saththianathan (1979)

(1) Nov. 24, 1949
(2) スリランカ大学（機械）
(3) ラクサパナ発電所機械技師
Mechanical Engineer, Ceylon Electricity Board, Laxapana Power Station, Laxapana, Sri Lanka
(4) "SENTHIL AKAM" Kaithady, South Kaithady, Sri Lanka

Mr. Sivakumaran Wignarajah (1978)

(1) Oct. 24, 1946
(2) セイロン大学（機械）
(3) コロナワ政府管理工場技術課長
Assistant Works Manager, Government Factory, Kolonnawa, Sri Lanka
(4) 81/2 Kynsey Road, Colombo-8, Sri Lanka

Mr. Laknath Wisantha Sepaal de Silva (1977)

(1) Jun. 18, 1950
(2) スリランカ大学（機械）
(3) セイロン製鋼公社製罐工場技師
Production Engineer, Rolling Mill & Fabrication Shop, Ceylon Steel Co. Athurugiriya, Sri Lanka
(4) 34 De Mel's Road, Laxapathiya, Moratuwa, Sri Lanka

Mr. Mohammadu Hannifa Mohammadu Farouk (1976)

(1) Oct. 30, 1941
(2) ロンドン工大（機械）
(3) 運輸省技官
Assistant Development Engineer, Ceylon Transport Board, No. 200 Kirula Road, Narahenpita, Colombo 5, Sri Lanka
(4) "Anver Villa", 17 Mosque Ave., Katugoda, Galle, Sri Lanka

Mr. Jayasuriya-aratchige Timothy Nihal De Saram (1976)

(1) Jan. 24, 1945
(2) 京都大学（機械）
(3) コロナワ政府管理工場技術部長
Mechanical Engineer, Heavy & Light Fabrication, Fitting, Smithy and Foundry Shops, Factory Engineer, Government Factory, Kolonnawa, Sri Lanka
(4) 27 Joseph's Place, Colombo 14, Sri Lanka

Mr. Pathirana Mayura Nimalsiri (1975)

(1) Jan. 18, 1949
(2) セイロン大学（機械）
(3) 運輸省中央工場技術課長
Engineer, Reclamation at the Central Workshops, Werahera, Ceylon Transport Board
(4) Kukulnape, Pallewela, Sri Lanka

Mr. Amara Jayawardane (1974)

(1) Jan. 22, 1943

(2) サウスバンク大学（機械）（英国）

(3) 公共事業省機械器具部第２技術課長

Chief, 2nd Engineering Section, Dept. of Machinery & Equipment, Ministry of Illigation, Power & Highway's, Sri Lanka

(4) 2 Illigation Bangalow, Ratmalana, Sri Lanka

（3）技術セミナー講演資料

1．セミナープログラム(SM-1)

2．セミナー出席者 (SM-2)

3．沓名団長セミナー資料

Education and Training Scheme of JICA Welding Technology Course (SM-3)

Progress in the Laser Application in Industrialized Countries (SM-4)

Metallurgical Aspect in Laser Welding of Steels and Aluminum Alloys

Recent Trends in Arc Welding Robot Application in Japan

Computer Aided Welding (CAW) System in Japan

4．野村技術指導セミナー資料

IIW Qualification Scheme for Welding Personal vs. Japanese One (SM-5)

International Standard (ISO) Ref.1 - 6

Proposal for Education, Training, Examination and Qualification System

For Global Trend / Market of Welding

Welding mechanization and autometion in shipbuilding worldwide

4．Ab. Ghalib H. X. Tham 主任研究員（SIRIM, MPTC）セミナー資料

The Prospect of Welding Technology in Malaysia (SM-6)

5．セミナー修了書 (SM-7)

SEMINAR IN WELDING TECHNOLOGY by JICA FOLLOW-UP TEAM

PROGRAM :

Date: 5th March 1997, Wednesday

Time: 10.30 a.m to 6.00 p.m

10.30 -	Registration of Participants	
11.00 -	Introduction	by SIRIM
11.05 - 11.10	Speech by General Manager of MPTC, SIRIM	Mr. Ab. Halim Ab. Rahman
11.10 - 11.15	Opening Address by Resident Representative, JICA	Mr. Ryuzo Nishimaki
11.15 - 11.30	Tea-break	
11.30 - 12.40	Lecture I : 1) Recent trends in Arc welding and Special welding application 2) Global trend /market of welding 3) Education and training scheme of JICA welding technology course - Q & A	by Dr. Muneharu Kutsuna
12.50 - 2.20	Break for lunch	
2.30 - 3.10	Lecture II : 1) Present situation of welding technology 2) Welding technology in Malaysia - Q & A	by SIRIM
3.10 - 3.30	Tea-break	
3.55 - 5.10	Lecture III : 1) Introduction of ISO welding standards corresponding to ISO-9000s a) Quality requirements for welding b) Welding coordination (welding engineers) tasks and responsibility 2) Draft of ®IIW education, training, examination and qualification system for welding personnel world wide 3) Proposal for education, training, examination and qualification system for welding personnel in accordance with ®IIW scheme conducted by ©JWES - Q & A	by Dr. Hirokazu Nomura
5.10 - 5.40	Closing address and Presentation of Certificate	by Dr. Muneharu Kutsuna

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SEMINAR ON WELDING TECHNOLOGY

PROGRAMME

Date : 12th March 1997
Time : From 1:30 p.m. to 5:30 p.m.

Venue : Serendib Hall,
Colombo Hilton.

1:00 p.m. Registration

1:30 p.m. Inauguration - Playing of National Anthems - Sri Lanka/Japan

1:35 p.m. Inauguration Speech -

1. Mr. Yoshiaki Kano, Resident Representative, JICA
2. Dr. Muneharu Kutsuna, Team Leader
3. Mr. B.H. Passaperuma, Deputy Director, ERD

1:45 p.m. Presentation (1) by Dr. Muneharu Kutsuna, Team Leader, JICA Follow-up Team.

1. Recent trends in Arc welding special welding application
2. Education and training scheme of JICA welding technology course

3:00 p.m. Tea Break

3:20 p.m. Presentation (2) by Dr. Hirokazu Nomura Member, JFT

1. Introduction of ISO welding standards corresponding to ISO-9000s
   - a) Quality requirements for welding
   - b) Welding coordination (welding engineers) tasks and responsibility.
2. Draft of IIW education, training, examination and qualification system for welding personnel world wide.
3. Proposal for education, training, examination, and qualification system for welding personnel in accordance with IIW scheme conducted by JWES.

4:00 p.m. Discussions

5:00 p.m. Closing Remarks by Dr. Muneharu Kutsuna

5:15 p.m. Vote of thanks by an Ex-participant

5:30 p.m. ~ 7:30 p.m. Cocktail party hosted by the Team Leader

Note:
JFT - JICA Follow-up Team
IIW - International Institute of Welding
JWES - Japan Welding Engineering Society
ERD - Department of External Resources

セミナー出席者（順不同）

1. MALAYSIA

NO.	NAME	ORGANIZATION
1.	Haji Idris Mohamad	CIAST
2.	Khamis Ujang	IKM Johor
3.	Abdul Ghalib H.K.Tham	SIRIM
4.	Dawot Hussin	SIRIM
5.	Saari Zakaria	Technic Teachers Training College
6.	Jumadi Giman	IKM Kedah
7.	Mohd Ali Shaik Dawood	IKM Kuching
8.	Mohd Razali Mohd Sidek	IKM Melaka
9.	Radzuan Nong	PUSPAKOM
10.	Zamin Mat Dain	KIM Lumut
11.	Mat Sainusi Nat Drus	Industrial Training Institute (ITI)
12.	Waji Risman	ITI
13.	Mior Md Salleh Mior Yusoff	ITI
14.	Zainal Hj. Yassin	MARA
15.	Yaakob Zainal	MARA
16.	Mohd Affende Jaafar	MARA
17.	Mohd Nasir Ariffin	MARA
18.	Abd. Rahim Yamman	MARA
19.	Idris Rukawi	SIRIM
20.	Jamil Abdullah	SIRIM
21.	Uzail Zawahir	SIRIM
22.	Abdullah Mohd	SIRIM
23.	Abd. Razak Zainal	SIRIM
24.	Abdul Halim Abdul Rahman	CIAST
25.	Shukri Che Hassan	CIAST
26.	Iffli Efendy Abdullah	CIAST
27.	Zulkifli Sarban Abdullah	CIAST
28.	Kamal Abu	CIAST
29.	Ryuzo Nishimaki	JICA Malaysia Office
30.	Eiji Sato	JICA Malaysia Office
31.	Kenji Tobita	JICA Malaysia Office

2. SRI LANKA

NAME	ORGANIZATION
1. I.A.K. PERERA	Min. of Labour & Vocational Institute
2. J.A.T.N. De Saram	Government Factory
3. B.A.V. Jayawardenn	Technical College, Kurunegala
4. T.A. Wickramesi	National Engineering Research & Development Centre
5. K. Sivananthan	Government Factory
6. D.C. Jayaratne	Industrial Estate Ekala
7. P.N.K. Dias	AETI, NAITA
8. Tukasa Murai	AETI (JICA Expert)
9. Takashi Niimura	Embassy of Japan
10. S.M. Pvnchi Barda	JICA Sri Lanka Office
11. P. Jayasekara	TIPS Ltd.
12. Rikiro Koriyama	JICA Expert
13. M.A. Nihal Perera	Hakkasaka Automation
14. P.R. Anthonis	University of Colombo
15. M.N. Perera	Browns Group
16. Junko Fujiwara	JICA Sri Lanka Office
17. Sumithra de Silva	JICA Sri Lanka Office
18. J.A.T.N. De Saram	Government Factory
19. K. Sivananthan	Government Factory
20. T.A. Wickremesi	NERD Centre
21. B.A.V. Jayawanden	Technical College, Kurunegala
22. T.A.K. Perera	Technical College, Ratmalana
23. J. Weerasinghe	Min. of Labour & Vocational Institute
24. S.M. Sathiacama	Ansell Lanka (Pvt) Ltd.
25. Chitral Jayawarda	JICA Alumuni Association
26. A. Sooriyagoda	Dept. of External Resorces
27. U. Amaratunga	Ansell Lanka (Pvt) Ltd.
28. A. Daharamawardena	Dynamic Technologies Ltd.
29. B.H. Passaperuma	Dept. of External Resorces
30. R.I. Samah Hige	NAITA
31. Z.M. Thalis	NAITA
32. S.M. Ratnaweera	Colombo Dockyard Ltd.
33. M. Perera	Colombo Dockyard Ltd.
34. U. Anuraddha	Colombo Dockyard Ltd.
35. Yoshiichi Keida	JICA Expert
36. S.L.P.Stambo	Industrial Dvelopment Board
37. P. Abdul Kazool	Industrial Dvelopment Board
38. Sunil S. Premasin	Industrial Dvelopment Board
39. L. Ananda Thilak Perera	NIVT
40. P.N.K. Dias	AETI, NAITA
41. Yoshiaki Kano	JICA Sri Lanka Office
42. NihalWijeyewickena	University of Moratuwa
43. J.D.P. Ahilhen	Airport & Aviation Sri Lanka Ltd.

Education and Training Scheme of JICA Welding Technology Course

by Muneharu KUTSUNA

Dept.of Mayerials Proc.Eng., School of Eng.,Nagoya University,Chikusa-ku,Nagoya, Japan

Abstract

In welding technology training couise organized by JICA(Japan International Cooperation Agency), eight or ten oversea participants every year have the oppotunity of education and training as an engineer. The welding technology training course has been established in 1974 at JICA's Nagoya International Training Center (NITC) as the first course.

The education and training in this course are quite similar to European scheme of education and training for welding personnels. The Qualification test for welding engineer for JICA participants is started by JWES(Japan Welding Engineering Society) since 1981. More than 220 perticipants had completed this education and training course since 1981.

1. Introduction

The importance of human resource development is widely recognized. Convinced of its importance,the Government of Japan established the Japan International Cooperation Agency (hereafter called as JICA) in 1974 as its sole agency for the implementation of Japan's technical cooperation with developing countries, with the aim of expanding this development co-operation in response to increasingly diversified requests from developing countries including Asian countries, Middle east countries, European countries, African countries, Oceanean countries and Mid-South American countries for technical cooperation, particularly in the area of human resources.

JICA is conducting such activities as education and training, expert dispatch, equipment supply, dispatch of cooperation volunteers and development survey with extensive cooperation from governmental and private organizations in Japan. JICA training programme for technical exports and engineers has been regarded as one of its three core activities. Under the training programme, which comprises both group training courses and individual training, JICA today accepts more than 6,000 oversea participants in around 400 group training course every year for training in Japan by Japanese experts in English language.

In welding technology course at NITC(Nagoya International Training Center), eight or ten oversea participants every year come to Nagoya and have the oppotunity of education and training as an engineer.

The welding technology training course has been established in 1974 at JICA's Nagoya international training center as the first course supported by Prof.Isao Masumoto(former prof. of Nagoya university,Dept.of Metallurgy), The Japan Welding Engineering Society, The Japan Welding Society, Nagoya University,and many companies and organizations.

The education and training in this course are very similar to European scheme of education and training for welding personnels. The Qualification test for welding engineer for JICA participants is started by JWES since 1981. More than 230 perticipants had this education and training course since 1981 as shown in Table 1[1].

Table 1 Number of oversea participants in welding technology training course of JICA

Country	'74	'75	'76	'77	'78	'79	'80	'81	'82	'83	'84	'85	'86	'87	'88	'89	'90	'91	'92	'93	'94	'95	'96	Total
Bangladesh	1			2	1	1	1				1													7
Burma	1		2	1	1	1	1	1		1	1	1	1	1	1									14
Kampuchea	1																							1
China								1	1	1	1	1	1	1	1	1	1	1		1			1	13
India							1	1	1	1		1	1	1	1	1								9
Indonesia	1	2	1	1	1	1	1		1					2						1				12
Laos	1	1																						2
Malaysia			1	1		1	1	1	1	1		3	1		1	1	3				1			17
Pakistan						1	1																	2
Philippines		1						1	1		1			1							1	1		7
Singapore	1	1			2	1		1	1	1		1												9
Sri Lanka	1	1	2	1	1	1	1			1	1		1	1	1	1		1	1					16
Thailand	1	1	1	1		1	1	1	1	1	1	1	1					1	2	1				16
Bhutan																							1	1
Egypt									1	1	1	1	1	1	1	1	1		1	1	1	1		14
Iran	1	1	1			1	1				1				1	1			1	1	1	1	1	13
Iraq			1														2							3
Syria												1	1		1	1		1						5
Sudan				1	1	1																		3
Turkey			1	1	1	1	1	1	1	1	1		1		1	1		1		1			1	15
Ethiopia									1												1	1		3
Ghana								1									1							2
Liberia			1																					1
Nigeria										1														1
Tanzania				1		1	1	1	1	1	1		1	1	1	1	1							12
Kenya																			1		1	1	1	4
Uganda	1	1			1																			3
Brazil											1	1	1		1	1								5
Argentine																			1	1				2
Chile								1										1						2
Paraguay												1	1											2
Mexico																							1	1
Panama										1														1
Jamaica																						1	1	2
Guyana																						1		1
Cyprus																1								1
Malta																		1		1				2
Fiji																	1		1		1	1		4
Nauru																		1						1
Solomon Islands																					1	1		2
Marshall Islands																						1		1
TOTAL	10	9	11	10	9	12	12	12	13	12	11	12	12	9	11	11	10	8	8	8	10	9	8	230

2. Course Outline

2.1 The objective

The objective of the training programme is to provide opportunities for participants to enhance their current technical and administrative skills and knowledge, thus enabling participants to continue to contribute significantly to their country's development. In addition to gaining technologocal knowledge, participants will have many opportunities to experience various aspects of life in Japan,while they are here. Participants are expected to take advantage of themand pass the qualification test for welding engineer conducted by JWES based on WES 1803. The mutual exchange of ideas with Japanese citizens are also important goal of the training programme.

Japan has given strong emphasis to the education and training programme, stressing the importance of high level training to meet more effectively the needs for managers,scientists, technicians, teaching faculties,and institutional leaders in all sectors.

The aim of this course is to bring up well-qualified engineers who are able to manage the welding construction and maintenance, and the course provides theoretical and practical knowledge of welding technology.

2.2 Needs for Education and Training

Welding technology is applied to various industries such as aircarft, shipbuilding,rolling stock, steel construction etc. Accordingly,current welding engineering does not simply require the manual skill of welders. The quality and reliability of welded construction are assured only when welding is carried out under the supervision of an engineer who has adequate knowledge and experience in welding technology.

Therefore, it is important to have qualified engineers who are able to manage practical and theoretical aspects of welding technology as apply to the day-to-day runnung of welding fabrication,construction or maintenance.

2.3 Education and Training in the course

By the end of training period (98 days), the participants are expected to have theoretical and practical knowledge of:

1. Welding processes and equipment	....	16 days	(112 hours)
2. Materials and welding metallurgy	....	16 days	(112 hours)
3. Construction and Design	....	10 days	(70 hours)
4. Fabrication and application engineering	....	16 days	(112 hours)
5. Fundamental practical skills/operatio	....	12 days	(96 hours)
6. Observation and practice	....	16 days	(112 hours)
7. Group training in industries	....	8 days	(56 hours)
8. Qualification test for welding engineer	....	2 days	(14 hours)
9. Others (Orientation etc.)	....	2 days	(14 hours)
total		98 days	(698 hours)

These education and training is implemented by JICA Committee (Chairman: Dr.M.Kutsuna,Nagoya Univ.) of JWES which is non-profit organization founded in 1949, under the authorization of the Ministy of International Trade and Industry(MITI), for the purpose of improving and promoting the spread of welding and other related technologies. This committee is sopported by several universities such as Nagoya Univ.,Osaka Univ.,Mie University,institutes, major private industries such as NKK, Nippon Steel Corp. Kawasaki Heavy Industries,Daihen Co.etc,and medium and small companies and their experts. Table 2 showsthe education and t raining system. This education and training system is satisfied enough with european scheme of education and training for welding engineer level by EWF(European Welding Federation).

For instance, the curriculum oftheoretical education of welding processes and equipment in the course is the same as that of EWF scheme as follows:

a) General introduction to welding technology
b) Historicals of welding processes
c) Fundamental of electricity and electric
d) Physics of welding arc
e) Power sources for arc welding
f) Manual arc welding with covered electrode(MMA/SMAW)
g) Introduction to gas-shielded metal arc welding(including MAG/MIG welding)
h) Tungsten-inert gas welding(TIG)
i) Submerged arc welding
j) Resistance welding
k) Electron beam and laser beam welding
l) Gas welding and other welding processes
m) Surfacing
n) Fully mechanized processes and robotics
o) Brazing and soldering
p) Thermal cutting and other edge preparation processes

Table 2 The edcation and training system of welding technology training course of JICA

JICA

NITC — arranged by JICA Committee of JWES

Welding Technology Training Course

A. Theoretical Education — Total 62 days
- Welding processes and equipmentWelding including introduction to welding technology — 16 days
- Materials and welding metallurgy — 16 days
- Construction and Design — 10 days
- Fabrication and application engineering including testing and inspection and safty and health — 16 days

B. Fundamental practice — Total 12 days
- Fundamental experiment at university
  - Mechanical tests & Charpy impact test
  - Observation of microstructures
  - Measurement of Hydrogen, etc.
- Fundamental practice at NKK Corp.
  - Practice for various kinds of Arc welding (SMAW,MIG/MAG,TIG,SAWetc)
  - Practice for Non-destructive test
- Fundamental practice for welding power sources (engine welder, resistace welder, semi-automatic CO_2 welder)

C. Group training in industries — Total 8 days
- Practical training in industries
  - Welding fabrication
  - Repair welding training
  - Welding of special metals and alloys

D. Observation and practice — Total 16 days
- Technical visit
  - to industries
  - to university or institutions

E. Qualification test for welding engineer of JWES — Total 2days
- Qualification test

F. The others
- Orientation and Evaluation of the course — 2 days

2.4 Methodology for the course

Lecture/discussions, problem-solving, comparative study, industries observation, practice, etc.are carried out in an effectively concerted manner in the process of acquiring skills. The training time allocation by instruction method is as follows

Lecture(58%), Workshop practice (22%), Observation (16%), Others (4%)

Arc welding (SMAW,MIG/MAG,TIG,SAW,engine welder)

Plasma welding / cutting,
Resistance welding,
Electron beam welding
Laser welding/cutting
Testing and inspection
(Tensile test,Bend test,
Charpy impact test,
. UT,RT,PT.MP,etc.)
Metallurgical observation
Hardness measurement
(Optical and Electron
microscopes)
Measurement of diffusible
hydrigen
(Glycerine method)

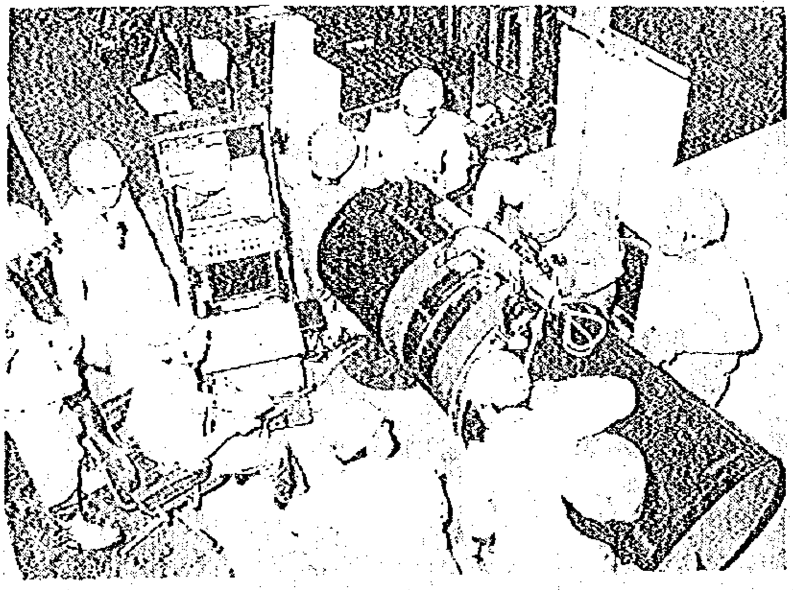

Fig.1 Scene of practical training on non-estructive test of arc welded steel pipe

The course is generally conducted in English by the experts using text book, OHP slides,and othre materials in English.

Figs. 1 and 2 show the scene of practical training at a private industry. In welding technology, experience is quite important to understand and use this technology in practice. In the group training at some private industries, actual specimen are used for the education and training.

Fig.2 Scene of practical training on arc welding robot

Teaching staffs are more than 30 experts who have a long experience and deep knowledge in the field of welding and work in different organizations such as universities, major private industries, medium/small companies and research institutions. In the practical training such as gas welding and soldering, skillful experts teach their techniques and know how using a welding equipments and specimens. In the case of teaching repair welding in practice, the participants visit to small companies in which repair welding is taken place dayly using over-laying and thermal spraying.

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Progress in the Laser Application in Industrialized Countries

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ABSTRACT

Laser is called as a" Quantum Machine" from its mechanism of generation after the development by T.H.Mainman on July 7,1960. We can now use this machine as a tool for manufacturing in industrialized countries. Recently, 45kW CO_2 laser and 5 kW YAG laser facilities are available to weld a heavy steel plate of 40mm in thickness and cut stainless steel of more than two inches in thickness. A general view of laser material processing applications such as welding, drilling, cutting, hardening, forming, cladding, alloying and micromachining are discussed in the present paper. In addition, the progress in the industrial applications of laser material processing in automobile industry, electronics industries, steel making industries, heavy industries in Japan, USA and EC countries are described. The impact of laser as a machining tool to industries for the future is also discussed.

1. Introduction

First application of laser of 1.72 W in power has developed in 1964 by M.Patel of Bell Institute. Nowadays, we have a powerful CO_2 laser of 45 kW which is about 28,000 times more than that of Patel's device. YAG laser was developed in 1964 by Geusic. Now, 4 kW YAG laser is available as an industrial tool. Fig.1 shows a 4 kW YAG laser developed by Ishikawajima Harima Industries Co.Ltd.,in Japan in 1995[1]. Powerful CO_2 laser , YAG laser and Excimer laser are used for material processing like welding, cutting, drilling, surface treatment, marking, forming, ablation and so on. Fig.2 shows the laser robot of 5 kW output power which was developed by Trumpf in Germany and Fiat Corp. of Italy for the application to automobile industry[2]. YAG laser robot is, in general, more cheaper than that of CO_2 laser robot, because in the case of YAG laser system a regular robot and an optical fiber are available as shown in Fig.3. Many car panels are cut or drilled by this YAG laser system in Toyota Motor Co.[3].

First application of laser material processing is the laser drilling of diamond die used for extrusion of wire in 1965 using Ruby laser with low power. However, One of the master thesis titled as " Study on Application of Laser for Surface Alloying" has been prepared by F.E.Cunningham at MIT in 1964. In 1960's, Many types of lasers were developed in the United State. And R&D for the power-up of laser facilities has been carried out mainly in the industrialized countries including the United State, United Kingdom, Germany and Japan. A high power 15kW CO_2 laser facility has been developed by UTRC and installed in the Naval Research Labo.at Washington DC in 1972 . This laboratory was leading the developing CO_2 laser technology for studying laser material processing. For example, welding and cutting of high strength steels like HY-110 and HY-130, aluminum alloys and titanium alloys in the thickness range of 5 to 20 mm. One of the reason to use laser power to join such materials is that powerful laser has many advantages as follows[4];

(1) High power density to get deep penetration as shown in Fig.4
(2) high productivity (high joining speed)
(3) Low heat input and minimum distortion of weldment as shown in Fig.5
(4) Heat source without mass ,but so many varieties of wave lengths
(5) No contact process and no wear of tool as shown in Fig.6 (laser marking)
(6) A precision heat source and machine,i.e. beam dia.: several microns
(7) Available to use in the atmosphere without X-ray radiation
(8) Clean and noiseless heat source which is suitable for FA and LA

Table 1 shows the historical aspects of laser science and material processing[5]. It is indeed quite attractive for us to use these photon energy as a laser beam for manufacturing in the future. In industrialized countries Color TV guns are assembled using YAG laser as shown in Fig.7[6]. In an electronics company like Philips Co., about 130 spots welds are required to complete the assembling. If laser spot welding can be used, low distortion and high production rate could be achieved. In Philips Co.Netherland, there is a "Laser Street". They are using about 100 laser systems in place of conventional resistance spot welding, because many laser system are installed in a line in their plant Nowadays, laser material processing is used in automobile industry, steel making industry, electric and electronics industry, and machinery industry as shown in Table 2.

2. Classification of laser material processing

When laser is absorbed by material, heating, melting and evaporation of materials occurs in a quite short time i.e. several ms or μs. Using this phenomena heating processes such as hardening, joining processes like welding and removing processes like cutting by laser can be available. These laser material processing are classified as shown in Table 3[5]. More than 50 laser material processing's have been already developed and most of them are used in various kinds of industrial fields as shown in Table 2.

< Laser Welding>

When laser power density is $10^{4} \sim 10^{5}$ W/cm2, a beam hole (=key hole) is formed in the molten pool so that a deep penetration can be obtained in laser welding. The effects of output power and welding speed on the penetration depth in laser welding of steels with helium shielding is shown in Fog.8[7.8]. 42 mm weld penetration was obtained using 45 kW CO_2 laser system at a travel speed of 10 mm/s. Fig.9 shows the joining speed in various welding processes. The joining speed at 40kW CO_2 laser power has nearly same as that at 45kW electron beam power which is 5 times higher than that of high power SAW with three electrodes. This means the laser welding process has remarkably high productivity. Laser welding is a high speed and precision welding process with low heat input and distortion. Laser soldering and brazing are used for joining of fine terminal lead to pad on ceramic substrate using YAG laser in manufacturing of FPIC and electronic components[9, 10].

< Laser Cutting and Drilling >

High energy density is obtained by focusing laser beam into very small diameter of several micron meters (min. : 5 μm) and this makes possible material removal processes. The 70% ~75% of laser application in materials processing is for cutting and drilling. Laser cutting speed is depends on the laser output power as shown in Fig.10[11]. 40 mm thick steel plate can be cut at a speed of 10mm/s by a 6kW CO_2 laser system. The thick steel plate can be cut without dross using high purity oxygen as a assist gas.

Laser cutting and drilling have the following features:

(1) High speed and production rate
(2) High precision cutting/drilling with low distortion and heat effect
(3) Possible to cut brittle thin materials without touching and pressing
(4) Very narrow cut karf (width), less than 300 μm

Fig. 11 shows a high alloy pipe (called as Stent) of 4mm in dia. for expanding blood vessel during medical operation with many fine slits as an example of laser fine cutting. Recently, laser cutting/drilling are applied to cut or to make holes in various kinds of materials including metals, ceramics, stone, polymers, paper, wood and textile. The thickness range of steels to be cut by laser is from 25 μm~40mm High quality and reliable laser cutting/drilling equipment have been developed for FA,i.e.CAD/CAM. And a personal computer controlled NC laser machine is now used in laser job shop in Japan. Fig. 12 shows the comparisons of each thermal cutting process in cutting of 6mm thick steel plate[12]. High power CO_2 laser systems are used for cutting of steel panel for bridge, building, ship and machinery.

Laser drilling are used to make fine holes in turbine blade of super alloys, diamond die, cigarette paper, a log for laser incising, print board, contact lens and ceramics. Excimer laser is used for making holes for cooling of substrate and grooves as a circuit in electronics industry. Fig. 13 shows a polyimide micro gear of 300 μm in dia for micro machine made by excimer laser. The accuracy of dimension is 0.2 μm. This process is called as laser ablation because of decomposition or evaporation of materials without melting by high photon energy of excimer laser (wave length is 100 μm to 300 μm).

< Laser Micro-processing >

Laser micro-processing's such as trimming, scribing, marking, repairing, balancing, wire stripping are now used in electronics(semiconductor) industry as shown in Fig. 14 [13,14.15]. Laser trimming is used for adjusting electric resistance to designed value of hybrid IC network, chip resistance and quartz vibrator. Scribing is used for making many grooves in silicon substrate of LSI and alumna substrate of hybrid IC to separate after making IC chips. Laser repairing of mask is used for effective removal of residual defects on hot mask. Recently, a high peak power and short pulse (pulse duration : 20 to 500 μs) CO_2 laser resonator was developed by Mitsubishi Electric Co. for micro drilling (through holes) of print board. Comparing with the production rate, laser micro-drilling is 200 times higher than using a drill (2 holes a second in conventional process).

< Laser marking >

Scan marking by cw and high frequency pulse YAG laser and mask marking by TEA CO_2 laser and pulse YAG laser as shown in Fig.6 are practically used recently and the application area is widely spreading. In the United State, marking is important for public service. For example, prevention of forging cosmetics in southeast Asian countries, storage safety of food stuff, to detect their products mark and so on. In Germany there is an obligation to mark serial numbers on cans and bottle cap of beer just after production. Fig.15 shows the examples of machinery part and stone marked by laser. It is expected that needs for marking of products will be increase in the future. Laser marking system is very convenient and flexible in changing the marks and is easy to storage the data as a floppy disk.

< Laser Surface Processing >

Laser surface processing such as transformation hardening, annealing, forming, alloying, cladding, surface melting, grazing, PVD and CVD have been developed in last 25 years. Laser transformation hardening of steel and cast iron is used for improving wear resistance of inner gear housing by General Motors Co. since 1973. Inner engine cylinder liner, Piston rings groove corner, ceramics turbo charger rotor shaft and clutch drum are harden by laser, nowadays as shown in Table 4 [16]. Laser cladding is applied to local cladding of machinery parts such as turbine blade shroud,engine valve and valve seat. The advantages of laser cladding are as follows:

(1) Minimize the thermal distortion of part
(2) Easy to control the bead shape and minimize the amount of powder used
(3) High quality due to the fine microstructures and homogeneous composition
(4) Full automatic and mechanized process
(5) Low dilution rate

Turbine blade of steam turbine is clapped or repaired by laser cladding of nickel or cobalt base alloys in Germany, France and Japan. Rapid prototyping using laser cladding has been developed by Fraunhofer Institute of Laser in Aachen.

Laser surface melting is classified into three categories by the cooling rate as shown in Fig. 16 [17]. Those are Normal solidification process, rapid solidification process and super rapid solidification process. The microstructures and homogeneity are determined by cooling rate. Amorphous metals can be produced in super rapid process of 10^6 ℃/s in cooling rate. In surface melting of stainless steel, the obtained microstructures are significantly different from that of Schaeffler diagram [18,19]. Laser dulling process of roller for steel sheet production is one of surface processing to get a high reflective surface of steel sheet.

Laser physical vapor deposition (=laser PVD) was used for compressor motor shaft of refrigerator in Japan. Al_2O_3 film is deposited on tip of aluminum shaft by laser. And laser chemical vapor deposition (= laser CVD) is used for writing of tungsten line or other metal line on prototype CI board. Recently laser lithography is used to make a model of polymer and metal from two dimensional data as a rapid prototyping in a short time in the field of casting technology.

3. Laser Applications in Industry

3.1 In automobile industry

In automobile industry the first application of laser processing was laser hardening of gear housing of diesel engine by General Motors ,Saginaw plant in 1973. The material is gray cast iron. The wear resistance was improved by laser transformation hardening. In 1982 transmission gear is laser welded at the assembly stage with low distortion and high production rate. Laser welding systems with multi-station are used to join automatic transmission gears. 3 or 4 second is enough to join a gear. Tyssen Steel Co. started to supply under body panel of zinc coated steel for Audi Motor Co. after laser welding of the panel since 1986 as shown in Fig.17[20]. Toyota Motor and Nissan Motor are using many laser welding systems in their plants. In place of the conventional arc welding, two 1.2kW CO_2 laser welding systems are used to fix the stator core of silicon steel at a travel speed of 40mm/s as shown in Fig.18 [21]. In 1980's, many application of laser processing's were developed in automobile industry as follows:

(a) Laser Welding
~ Automatic transmission parts (gear, planet carrier, tappet housing)
~ Stator core of motor and pulley (Nippon Denso Co.)
~ Tailored blanks for door panel, sun roof and center pillar as shown in Fig.19[22]
~ Fuel tank, steel wheel, injector and break plates

(b) Laser cutting and drilling
~ Laser cutting of proto-type car body panel (1984,Toyota)

- Steel panels/parts and polymer parts
- Antenna hole for radio as an on-line process
- Laser drilling of camshaft and locker room

(c) Laser surface treatments
- Laser hardening of rotor shaft (Nissan Motor Co.)
- Laser cladding of engine valve since 1988 (Toyota Motor Group)
- Laser cladding of engine valve seat since 1994 (Toyota Motor Group)

(d) the others
- Rapid prototyping for making a original mold

About 300,000 engine valves per month are clapped by 10 automatical CO_2 laser cladding systems in Aisan Indust.Co.as shown in Fig.20[23]. Laser cladding of engine valve seat using copper alloy powder made an improvement of car engine quality.

Recently, most car manufacturers and their part suppliers are using so many laser systems. In Nagoya area of central Japan,where Toyota Motor Co. and Mitsubishi Motor Co.are located, more than 750 CO_2 and 500 YAG laser facilities are used in the industries. For instance, Toyota Motor has now about 120 laser facilities.

3.2 In steel making industry

Laser welding and cutting are commonly used in steel making industry. For instance, one of main Japanese steel makers introduced CO_2 laser for coil build-up before pickling stage to make thin sheet by cold rolling at the speed of Shinkan-sen (about 230 km/hour) since 1981[24,25]. Laser welding of stainless pipe is used in pipe production line in Germany and Japan since 1989[26]. The intergranular corrosion is limited and large deformation after welding is available. NKK Co. is using 25kW CO_2 laser welding system at their production line of pipe. In addition, light panels such as honeycomb panel and sandwich panel are now laser welded for the parts of vehicles and constructions like high speed ship with hydrofoil and TGV car floor [21]. Laser surface treatments for steel and non ferrous metals are used for metallurgical and physical modification of surface. Laser treatment of silicon steel surface to make fine magnetic domain to reduce the iron loss of motor core using a YAG laser in Japan[22]. Laser dull treatment of roller for steel making was developed by two main Japanese companies using CO_2 laser and YAG laser in 1980's.[23].

3.3 In electric and electronics industry

Electric and electronics industries started to use power lasers since 1970 to join their parts in place of resistance spot welding and other processes. Phillips Co. might have more than 100 YAG laser resonators to join and assemble their electric and electronics part. The total spot welds is accounted more than 10^{11} points in a year. For instance, electron guns of color TV are assembled by Laser spot welds of 130 as shown in Fig. 7. The advantages of laser spot welding are to minimize heating area and distortion of weldments.

A metal mask, which is called as a stencil and used to print soldering cream on the print board of IC, is made by laser fine cutting as shown in Fig.21. One of laser job shops in Japan is making many kinds of metal mask in 24 hours after getting an order and the cutting data through internet system using YAG laser.

3.4 In shipbuilding and heavy industries

If man looks into heavy industries including ship building and energy industry, laser is used to cut and weld various machinery parts of products. For example, AVCO company, Lycoming division uses pulse CO_2 laser to weld annular core parts of heat exchanger of AGT 1500 turbine engine of M1 type tank[27]. And they make 450 pair of weld assembling per day in two shifts. Titanium frame of compressor of turbofan engine was welded by CO_2 laser by IHI Co. Laser cutting /welding of Gas turbine and steam turbine components have some advantages of low production cost and high quality of parts due to low heat input and full automation systems. Laser heat treatment of piston ring groove of diesel engine and laser cladding of turbine blade for steam turbine is now used in Europe and Japan.

For the nuclear energy plants laser welding of control rod of nuclear reactor, tube plate to tube of heat exchanger of reactor has been considered. Laser welding of Zircalloy 2 or 4 tube and nuclear fuel control rod cluster are now applied in Japan[28], and laser robot for pipe cutting of used nuclear plant [29] has been developed. A high power YAG laser welding system with a optical fiber of 200 m in length was developed to repair the damaged sections of heating tube in a steam generators for PWR by Mitsubishi H.I.Co[28].

In May 1996 at Glasgow in Scotland, an international conference on "Exploitation of Laser Processing in Shipyards and Structural Steelworks" was held . A draft of guidelines for the approval of CO_2 laser welding for ship construction was presented by five European ship bureaus such as Lloyd,Norske Veritas,and Germanischer Lloyd which permit to the shipyards the use of laser welding of ordinary butt and T-joints in ship construction after procedure approval test and examination of first production welds[30]. A report on introduction of lasers to shipyard including cost estimation made by Odense Steel Shipyard Ltd. in Denmark showed that by today's technology it was only the plate thicknesses,which puts the upper limit for laser cutting applications. An comparison of production costs when using laser welding compared to conventional processes showed that savings are at least 50% of the conventional techniques. Mostly this is due to savings in labour costs because of higher joining speeds and a huge reduction of filler wire costs[31]. In ASME Code Section IX, laser welding is permitted as one of the welding processes for pressure vessel and pipe. Essential values for laser welding are required to assure the quality of weldments. A draft of laser welding for JIS are now preparing in Japan for steel structures and vessels .

3.5 In the other industries

In steel construction industry high power CO_2 laser cutting systems are running for cutting of steel panels of bridge and building. For instance in NKK Tsu works large members such as diaphragm ,web and transverse rib of 9 to 14 mm in thickness are cut in line A, and small members such as gusset plate and stiffener are cut in line B using 3kW CO_2 laser systems. The working area is 3.6m x 40m and 2.6m x 37m,respectively[32]. Many other industries are now using laser material processing using CO_2 laser, YAG laser and excimer laser in industrialized countries.

4. Summary

Recently, the application of laser materials processing(=LMP) is getting to spread into the industries mainly in industrialized countries such as Japan, the United States and European countries. For instance, many applications of LMP to the electric/electronics, automobile and steel making industries can be found in Japan since 1980. The total numbers of CO_2 laser facilities is statistically 8,000 and that of YAG laser is about 6,000 in Japan. Laser technology is getting more important tool in our society and it will be key technology inthe next century. It is true that distortion of weldment can be reduced by laser technology. The wave to use laser material processing has already started from electronics industry and automobile industry. This wave will be come to shipbuilding industry in the near future.

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Table 1 Historical aspects of laser sience and material processing

Year	Topics in laser sience	Topics in laser material processing
1900	"Quantum hypothesis of energy" by Max Plunk, FRG	
1917	"Emission and Absorption of Radiation in Quantum Theory" by Albert Einstein, FRG	
1951	"Idea of MASER by microwave" by C.H. Townes, USA	
1954	"Microwave Amplification by Stimulated Emission of radiation" presented by C.H. Townes, USA	
1957	Patent application of semiconductor MASER by J.Nisizawa, Japan	
1960	First generation of Ruby LASER by Theodore H.Maiman, USA	
1960	He-Ne laser by A.Javan, USA	
1961	Glass laser by Switzer, USA	
1964	1.72 W CO2 laser by C.K.N.Ratel at Bell L. Nd:YAG laser by Bell Laboratories, USA	
1965		Coherent Co. marketed 100W CO2 laser system First application of laaser for drilling of diamond die
1966	Die laser by Lempicki, USA	
1967		Development of 8 kW CO2 laser by Raytheon Co.USA
1969	CW Chemical laser by COOL, USA	
1970	Generation of Ultraviolet laser using liquefied Xenon by D.G.Basov, USSR	Fast axial flow type CO2 laser by Tiffany, FRG
1972	Excimer laser by J.J.Yuing, USA	Cross flow type 20kW CO2 laser was developed by UTRC, UAS
1973		Laser transformation hardening of gear housing of car, G.M., USA AVCO marketed 10kW CO2 laser
1976	X-ray lithography(SOR) by IBM, USA	Quanta-Ray introduces the first reliable YAG laser
1977		Laser hardening of cylinder linner of diesel engine for car by GM Starting of Japan national project" Flexible manufacturing system using high performance lasers"
1981		Laser welding of steel on line by Kawasaki Steel, Japan
1983		CAD/CAM system for cutting of electric machine panels, Toshiba
1984		Laser robotic cutting of car body at the stage of assembly line at the assembly line, Toyota Motor, Japan
1987		UTIL marketed 25kW CO2 laser, 1.4kW YAG laser by NEC and Toshiba, Japan
1988		3 kW CO laser developed by Laser Research Institute and MHI,
1990		20 kW CO laser developed by LRI and Mitsubishi H.I., Japan
1996		10kW COIL developed by Kawasaki H.I., Japan

Table 2 Laser material processing in production

Application fields	Laser material processing: Joining/ Welding	Cutting / Drilling	Surface processing
Electric	Lithium battery, Relay, TV-tube,fan,control panel, motor case,	Transformer panel,	PVC of motor shaft for refrigerator,
Electronics	IC package, IC lead, Sealing, Soldering of flat IC, computer parts, IC cartridge	Trimming of resistance Scribing of IC wafer, Marking of package, Repairing of mask	Drawing of HIC Annealing of IC
Automobiles	Transmission gear, AT parts,tailored blank,fly wheel,fuel tank,clutch disk, seal metal, pulley, motor core/yoke, metal gasket	Drilling of cam shaft, diaphragm for horn, Cutting of polyester resign,dash panel, bumper, Marking of car number on parts	Harden. of piston ring, gear housing, engine cylinder, AT parts, valve guide, tappet housing, Cladding of engine valve,valve seat
Steel making	Steel coil, steel pipe and titatium pipe, tin can, metal catalyst	Cutting of steel plate, and pipe, Marking of plate and pipe	Refining of magnetic domain of Si steel, Dulling of work roll
Machinary	chain saw, sealing of percussion cap,	Cut. of machine parts, Drilling of diamond die Marking of hard tools,	Harden.of lathe table, saw teeth,
Shipbuilding and heavy industry	heat exchanger, tube to tube plate, corrugate panel, turbine stator, Repairing of tube of generator	Cut.of ship hull/panel, turbine stator Drilling of turbine blade,	Harden. of cylinder line, piston ring Cladding of turbine blade and nuclear fuel rod
Precision machinary		Trimming of quartz, vibrator,cut./drilling of quartz ,ruby and liquid crystal	
Aircraft and Space	Honeycomb panel, thin tube, bellows	Cutting of Al alloy steet Drilling: turbine blade	Hardening of engine cylinder, Cladding of turbine blade shroud
Light industry	Ball pen cartridge, coffee percolater	Cut.of die board,textile ,composite materials Drilling of contact len's, cigarette paper, airsol valve,vinyl hose,	

Table 3 Classification and application of laser material processing

Processing		Porposes and Application field of the processing
Joining	Welding	butt welding of steel coil, welding/assembling of electric parts, automobile parts like mission gear, machinary parts,
	Soldering/Brazing	soldering of electronics (IC) parts, fan parts,
Material removals	Cutting	cutting of ferrous/non ferrous materials,glass,textiles,wood,
	Drilling	drilling of cigarete paper,steel panel, diamond die, tool,parts
	Micro removal	scribing, trimming, reparing of IC , balancing of motor
	Marking	marking of IC package,machinary parts, bottle,tool,steel,etc
	Ablation	wire stripping of lead to printer, via hole drilling,
	Machining / Caving	machining of ceramic screw, turning/milling of ceramics,etc caving of metal die,
	Cleaning	removal of oxide film, graphite on hetaing roller of printer,
Surface processing	Hardening	hardening of engine cylinder linner,piston ring,crankshaft,
	Annealing	stress relieving,single crystallization of polysilicon,
	Solution treatment	desensitization of stainless steel welds,homonization
	Alloying	carburization, nitriding, alloying of Cr,Si, W and Hf etc.
	Cladding	cladding of turbine blade and engine valve, inner tube,
	Surface remelting	remelting of metal layer, dressingof weld toe,dulling,glazing
	Laser CVD	formation of superconductor film and diamond film
	Grain refining	magnetic momain refining of silicon steel, refining of casts
	Impact hardening	impact hardening of Al alloy and Cu alloys by shock wave
	Drying	drying of the ink from paper after printing,
	Laser PVD	ceramics coating, formation of superconductor /oxide films
	Laser lithography	polymer film deposition on a substrate, rapid prototyping
	the others	laser assisted plating, laser assisted etching,
The others	Forming/ Bending of plate and pipe	plate bending of metal sheet, forming of metal sheet/pipe 0
	Laser assisted machining	hot machining of titanium alloy or superalloys to increase themachiningspeed
	Tearing/ Breaking	tearing of glass, breaking of stone or concrete

Table 4 Laser transformation harening on ferrous alloys available from literatures

Parts	Materials	Laser power, kW	Beam formation	Travel speed	Absorbing coating	Case depth μm	Hardness HRc
Spacer	Malleable cast iron	15	12.7x12.7 square	-	Graphite	305	58
Piston ring	Grey cast iron	6	12.7x12.7 square	-	Graphite	381	-
Valve seat	Cast iron	3	-	-	-	762	-
Cam shaft	Ductile cast iron	10	-	-	-	1015	60
Shaft	AISI 4140	10	Annular	12.7	-	381	55
Spline gear	-	10	Annular	12.7	-	381	-
Crankshaft	Ductile cast iron	13	Focused onfillet	-	-	1015	55 - 62
Cylinder	AISI 4140	7.5	Annular	3.7	Black paint	1523	45
Cam shaft	Ductile cast iron	9	23 x 25 rectangula	12.7	Manganes phoshate	560	50 - 55
Gear teeth	AISI 1045	8.8	12.7x12.7 square	8.5	Black paint	1165	59 - 60
Shaft (9.5 mm in dia)	AISI 1060	0.5	-	-	-	508	62 - 64
Cutting blade	AISI 1050	0.5	-	-	-	381	60
Cylinder liner	Grey cast iron	1.5	-	-	-	-	55 - 60
Bearing component	Grey cast iron	1.5	-	-	-	457	-
Power ste. gear housi.	Ferrit.malleable iron	1.0	Ring mode 1.8mm dia.	42	Manganes phoshate	254	-
Cut-out cam	AISI 4340	1.2	-	-	Graphite	381	-
End connector	AISI 4140	4	-	5	Krylon 1602	305	55
Plate specimen	SK5 steel	1.3	12.7 x 12.7 Square	-	Manganes phosphate	889	850 Hv
Cylinder liner	Cast iron	5	19mm in dia.	-	Black coating	635	
Specimens	0.3-1.1%C steels	1.8	5 x 5	25	Zinc phosphate	200 - 1400	450Hv - 1400

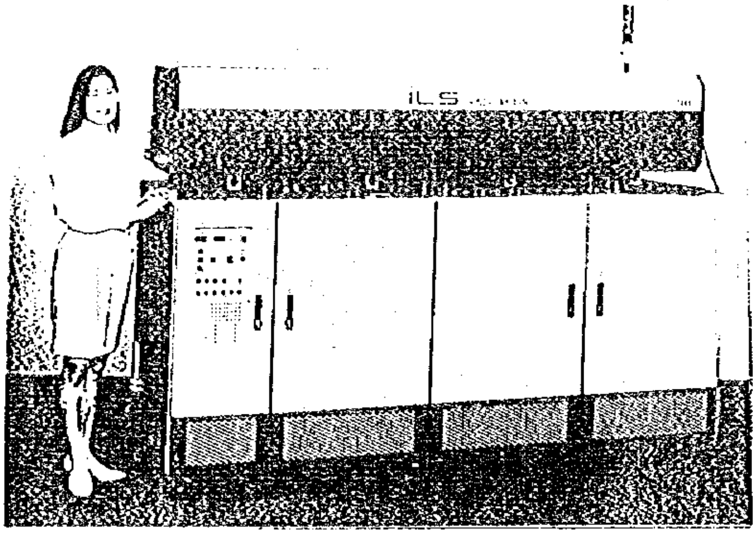


Fig.1 4 kW YAG laser developed by I H I Co last year.

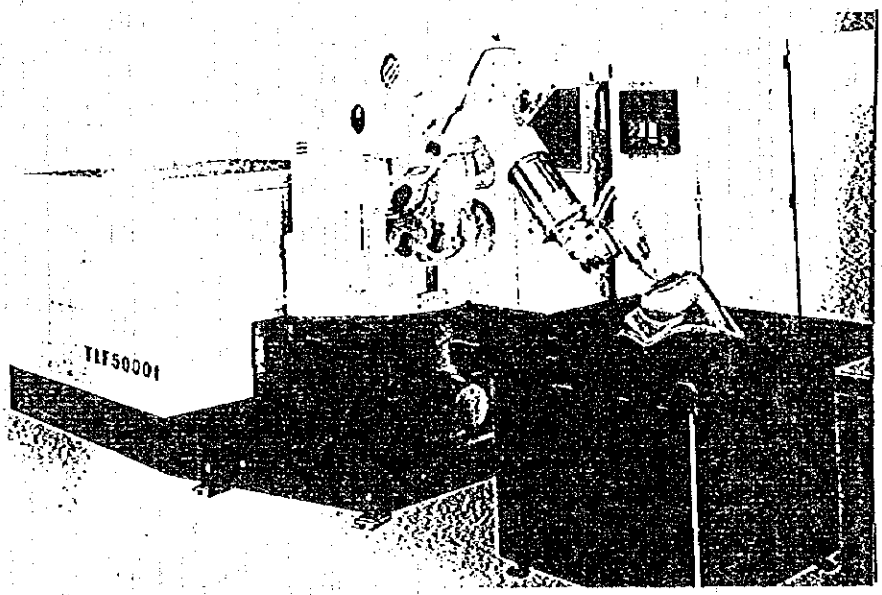


Fig.2 5kW CO2 laser robot developed by Trumpf Co and Fiat Co

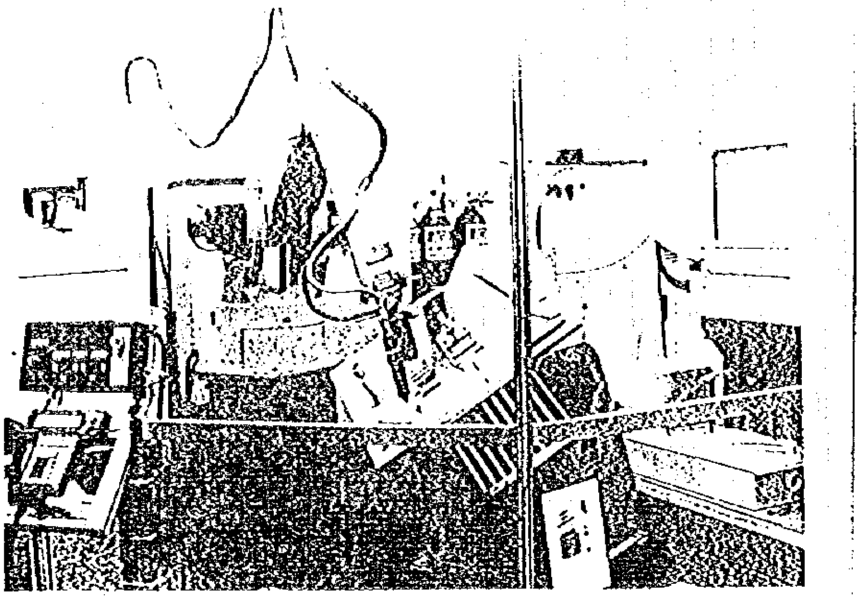


Fig.3 YAG laser robot system using a regular robot and an optical fiber

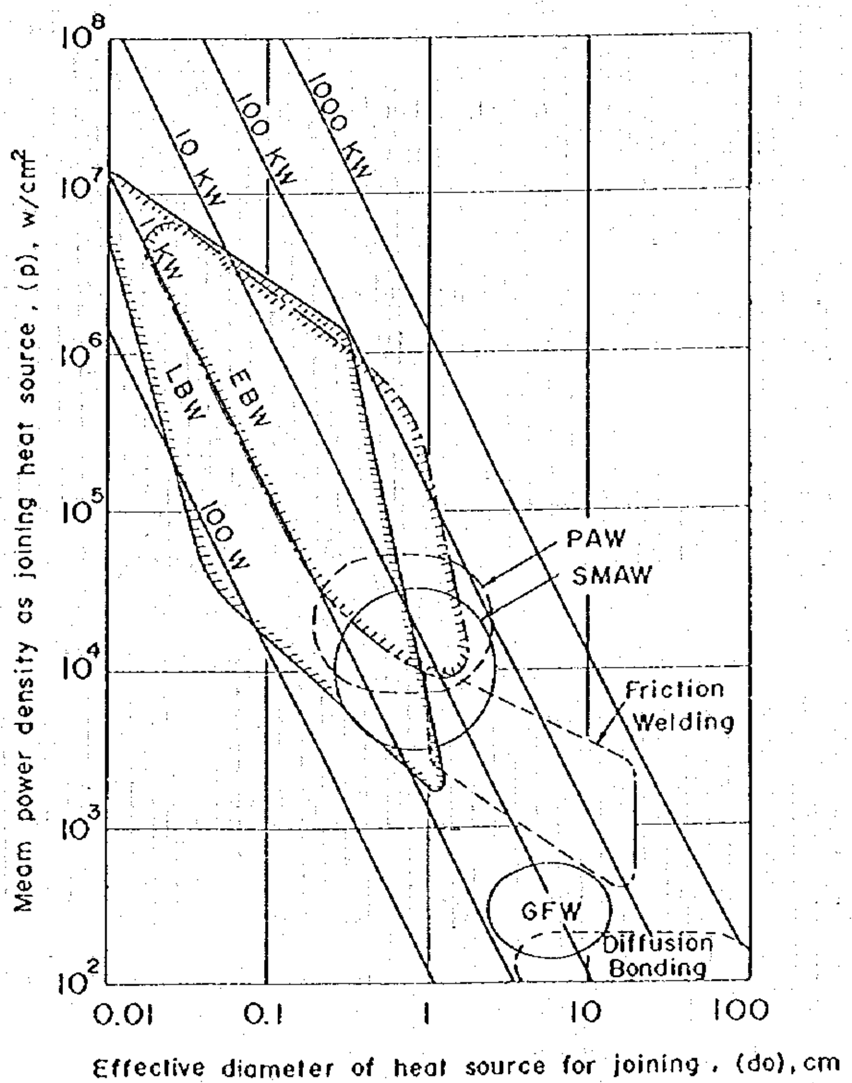


Fig.4 Power densities of different heat sources for welding

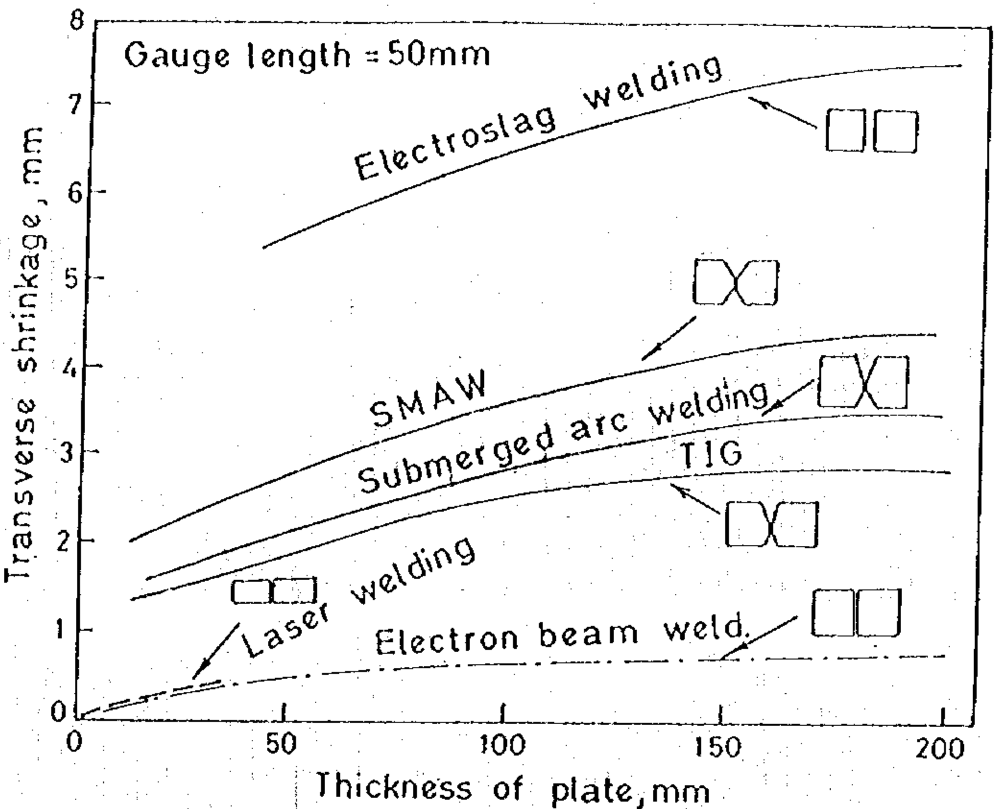


Fig.5 Distortion of weldment after different welding processes

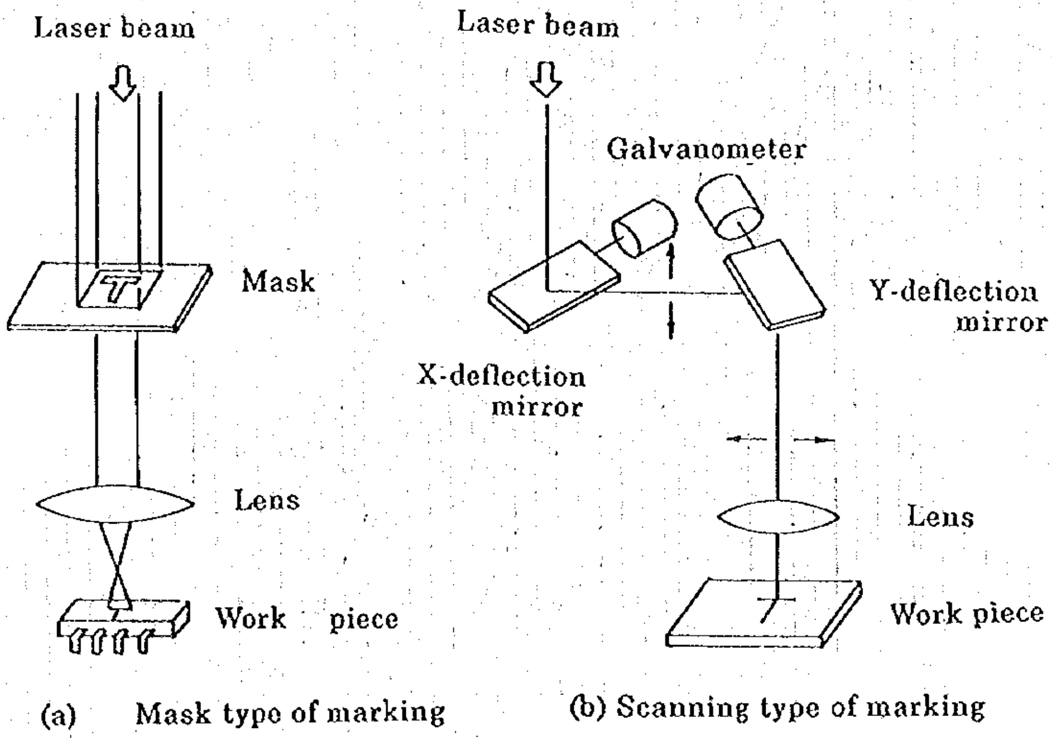
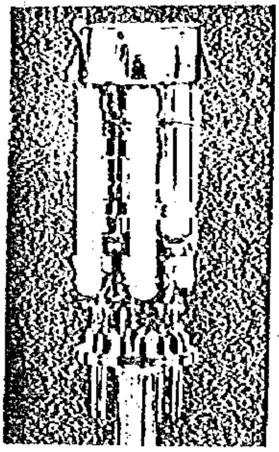
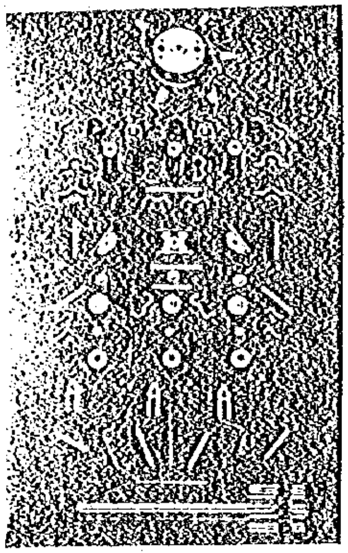


Fig.6 Laser marking as an example of non contact process and no wear of tool



(a) A set of parts for TV gun



(b) After assembling of TV gun by laser spot welding

Fig.7 Laser spot welding for assembling Color TV guns using YAG laser

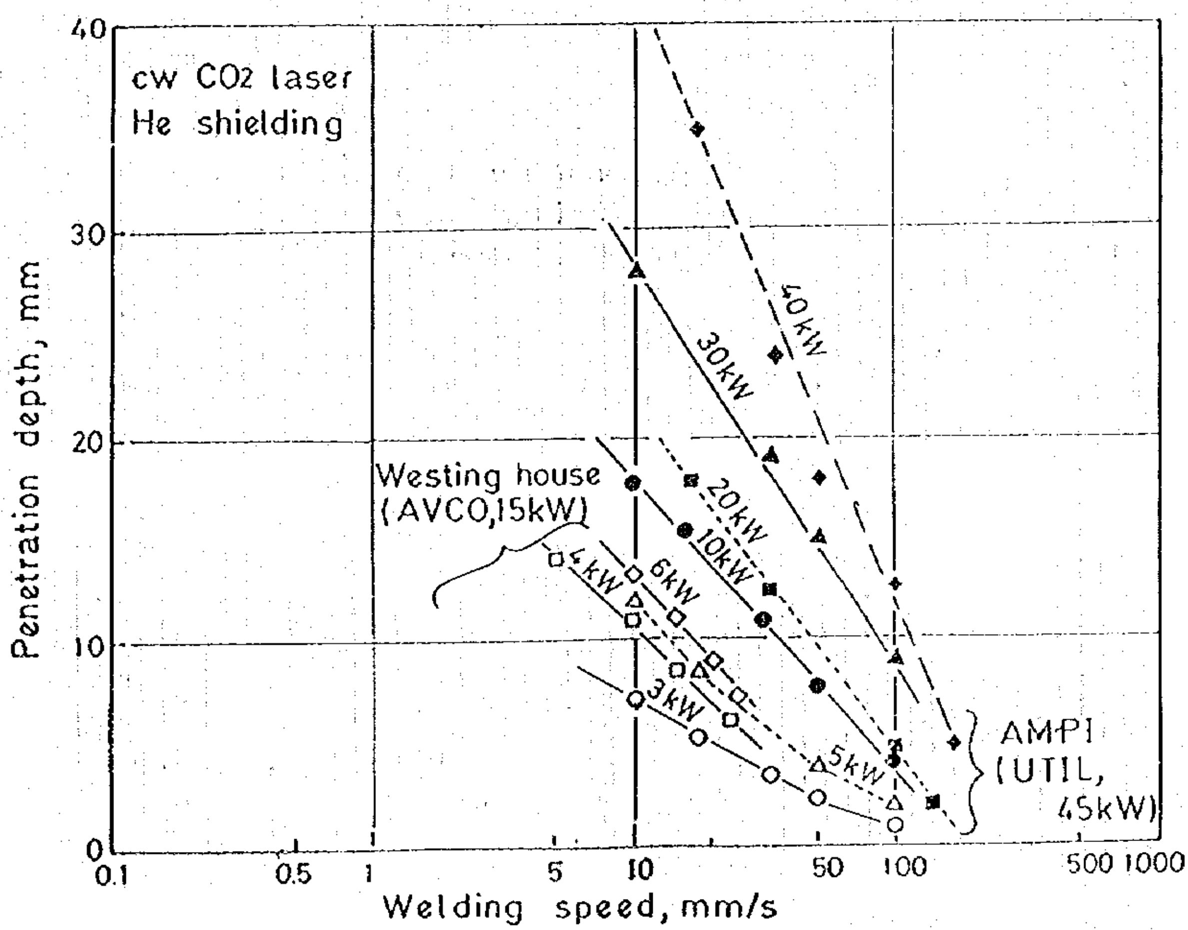


Fig.8 Effects of output power and welding speed on the penetration depth in laser welding

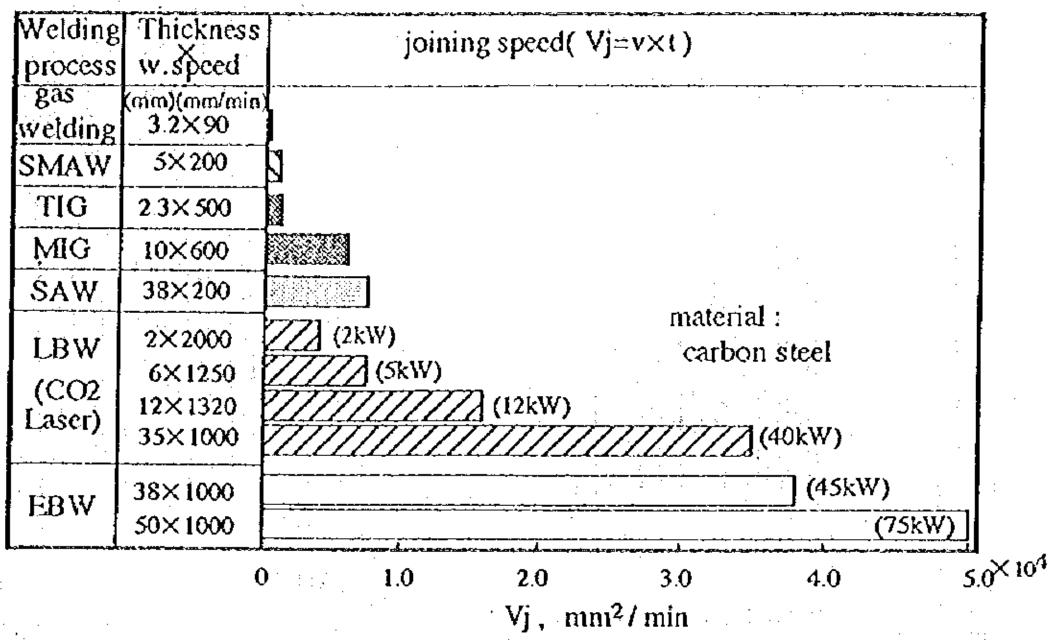


Fig.9 Joining speed per minute in various welding processes.

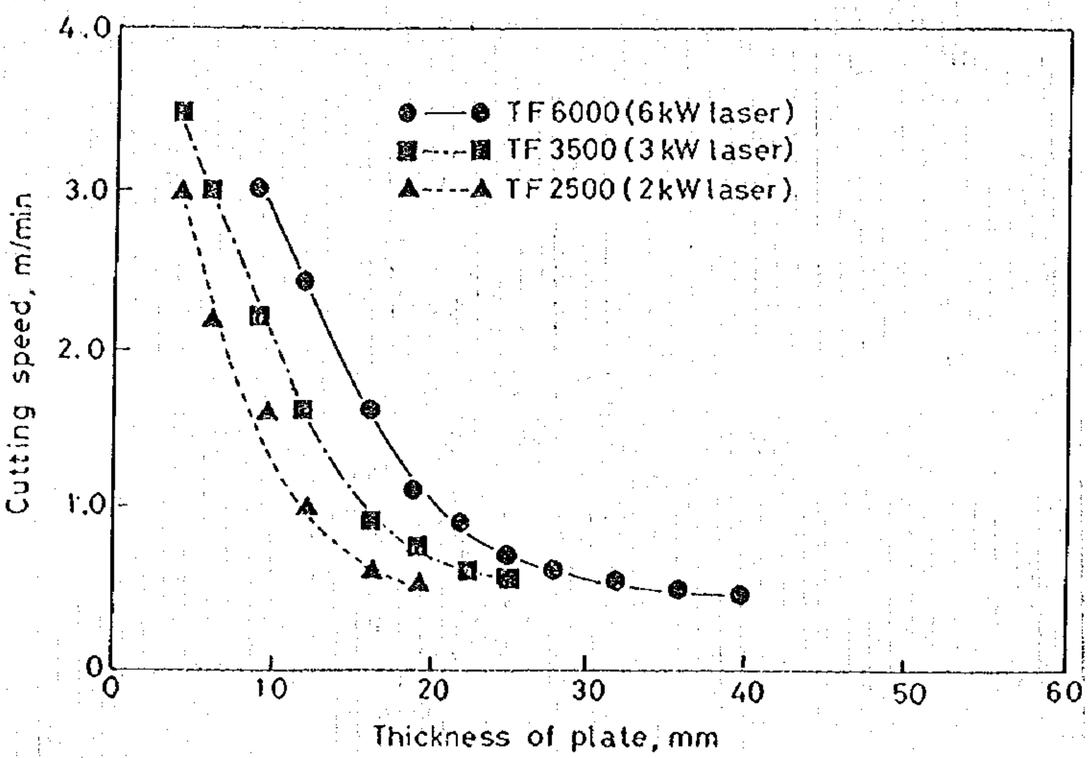
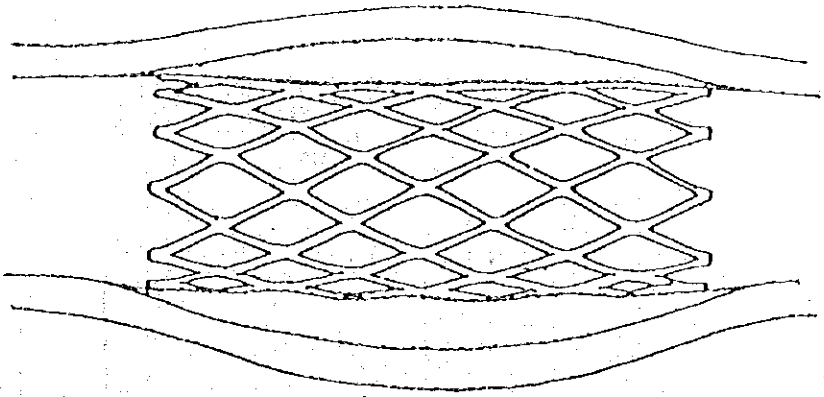
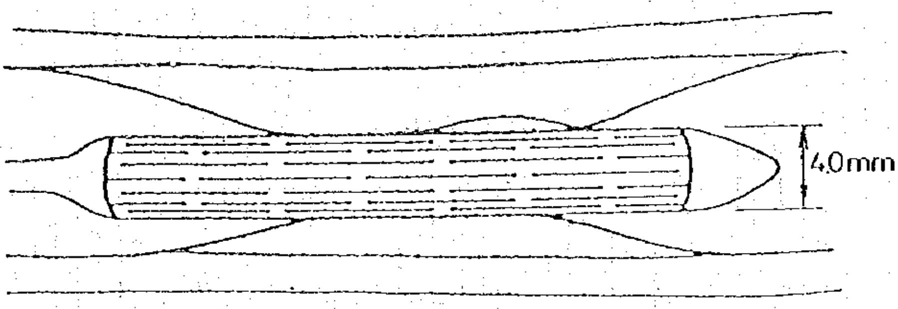


Fig.10 Cuting speed in CO_2 laser cutting of steel



(b) after applying pressure in a human blood vessel



(a) before applying pressure in a human blood vessel

Fig.11 A high alloy pipe (called as Stent) of 4mm in dia. prepared by YAG laser

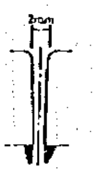
Items	Laser Cutting	Plasma Conventional	Cutting Air plasma	Gas cutting
Heat Source	Photon (Laser)	Arc (plasma)	Arc (plasma)	Chemical energy
Energy density	Very high	High	High	Low
Cutting gas	Oxygen, Nitrogen, Ar.	Argon + N_2 or H_2	Air	Oxygen + Acetylene Oxygen + Propane
Initial Cost	High	Fair	Low	Very low
Running Cost	Fair	High	Low	Fair
Cut Quality (t=6mm) Carbon steel Stainless Steel Aluminum alloy	 Excellent Excellent (thin plate)	 Fair Good	 Good Fair	 Fair impossible
Shape of kerf Example: Mild steel (t=6mm)				
Cutting speed	High	High	Fair/Low	Low
Manual Operation	Ipposible	Not easy	Easy	Easy

Fig.12 Comparisons of each thermal cutting process in cutting of 6mm thick steel plate

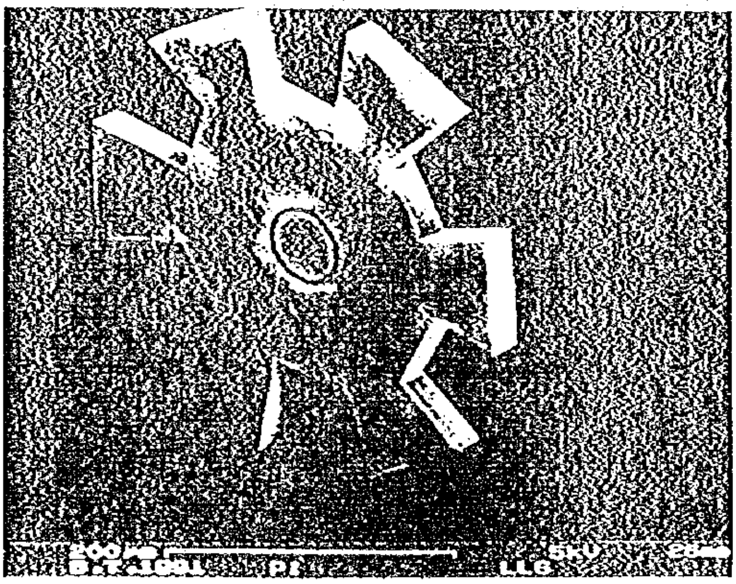


Fig.13 A polyimide micro gear of 300 μ m in dia for micro machine made by excimer laser.

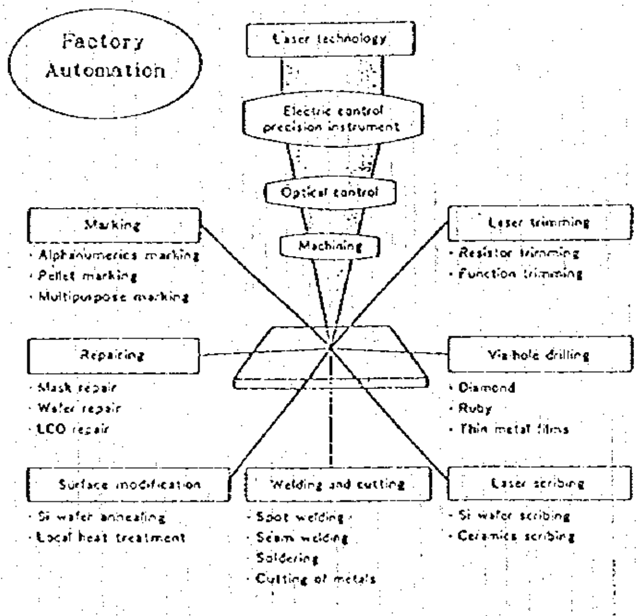
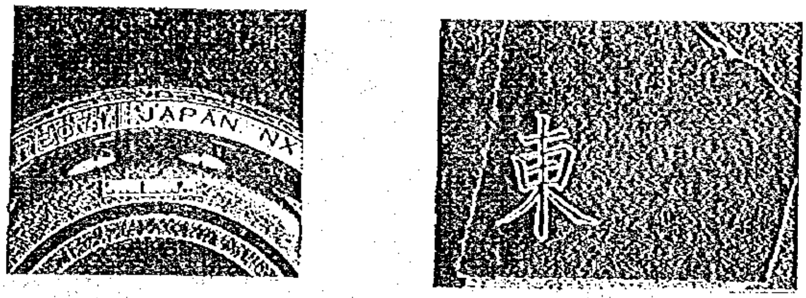


Fig.14 Laser micro-processing's used in electronics (semiconductor) industry[13]



(a) machinery part (b) stone (marble)

Fig.15 Examples of laser marking

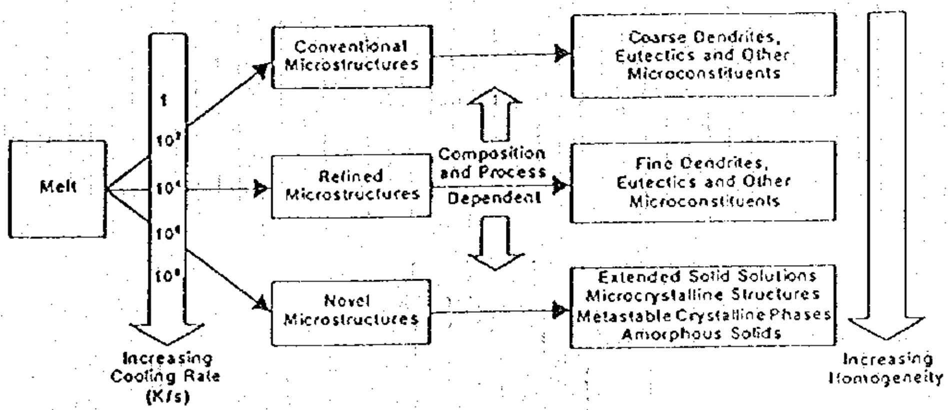


Fig.16 Laser surface meltings classified by the cooling rate[17]

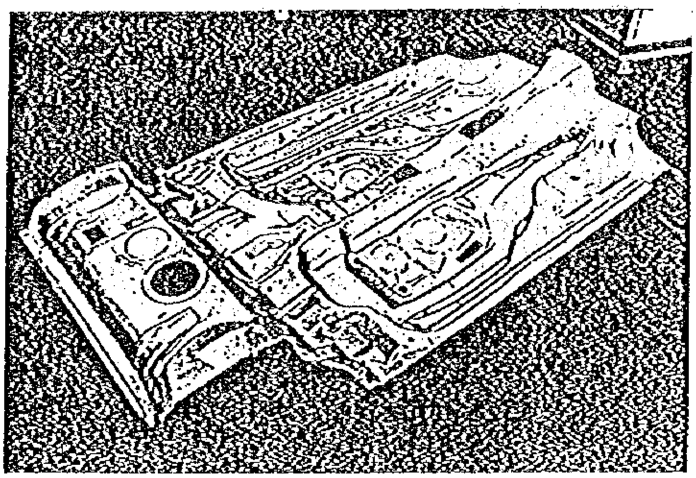


Fig.17 Under body panel of zinc coated steel for Audi 5000 after laser welding

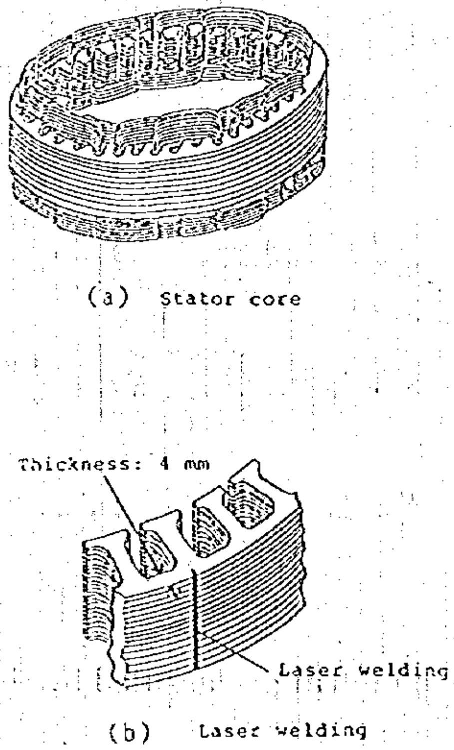


Fig.18 A stator core of motor for car welded by laser at a travel speed of 40mm/s

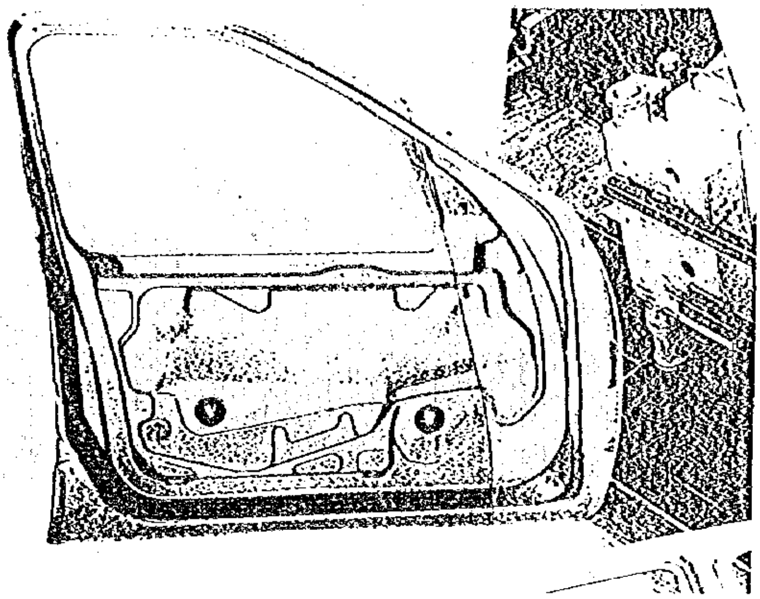


Fig. 19 Tailored blanks for door panel [22]

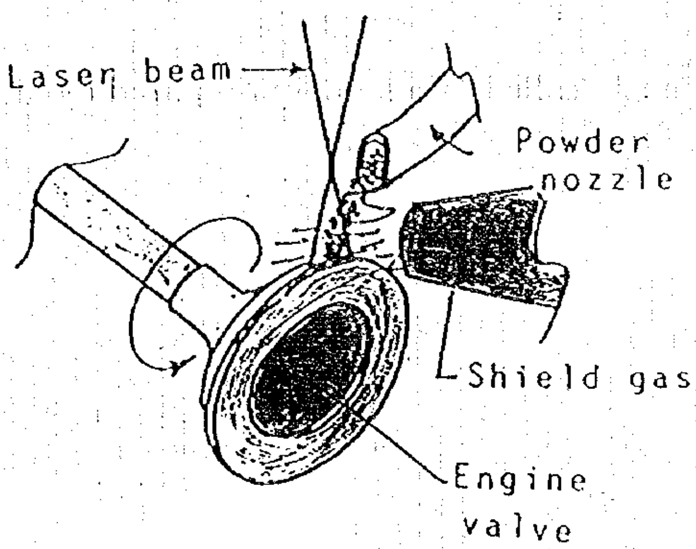


Fig. 20 Engine valve cladded by CO_2 laser cladding systems

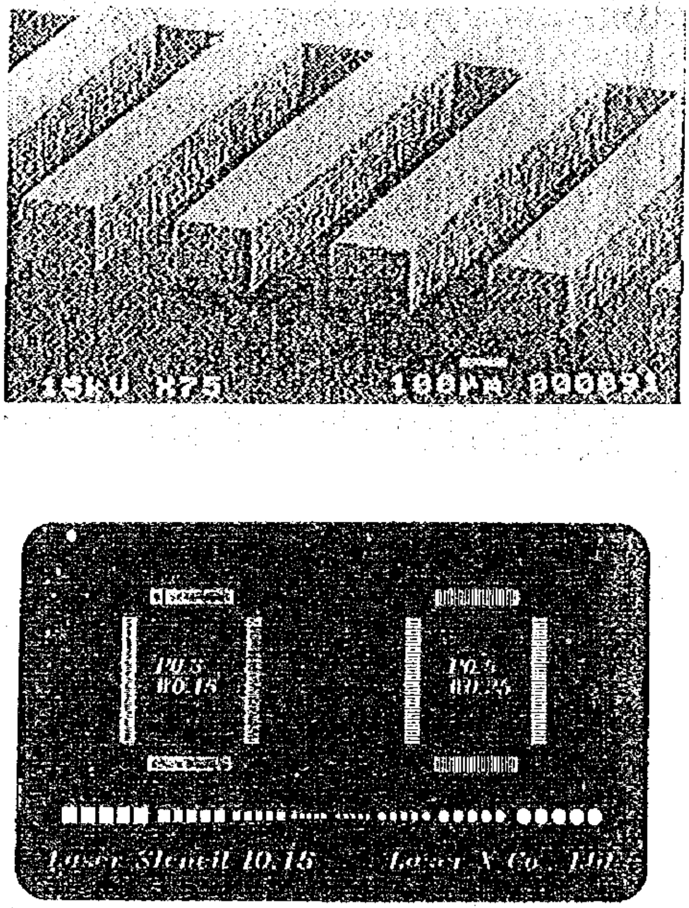


Fig.21 Metal mask (called as a stencil) prepared by laser fine cutting