TRENDS IN JOINING, CUTTING AND A SUSTAINABLE WORLD

BERTIL PEKKARI

ESAB AB, Box 8004, SE-402 77 Gothenburg, Sweden

Presented at International Welding Conference (IWC-2001) on Advances in Welding & Cutting Technology held on 15th–17th February, 2001 at New Delhi.

ABSTRACT

The latest improvements of existing joining processes and new and emerging processes like Tandem MAG Welding, Hybrid Laser MIG/MAG Welding, Magnetic Pulse Welding, Friction Stir Welding and mechanical joining techniques will be briefly covered. All these developments aim at increased productivity, higher and more consistent quality and improved working environment. In addition a sustainable environment has become an important element in all our private and professional actions.

INTRODUCTION

There are general trends, which will also encompass the joining and cutting world. The future scenario will cover eg.

- Increased use of IT as a power tool
- Circular business systems; closed resource flows and sales of complete systems
- Importance of intellectual capital will increase
- Globalization will be a must; local to global
- Focus on trademarks and core competences
- Customer is the king, tailormade equipment will increase requiring modulized systems.
- New processes will offer more options and will be faster implemented

Besides these trends there are continuous improvements introduced. Much of trends and the evolution of the current processes you will note in the presentation, which will be briefly illustrated in this paper.

CHANGES IN ARC WELDING PROCESSES

There is a continuous process change from Manua l Metal Arc (MMA) welding to MIG/MAG processes with solid and cored wires, which Fig.1 illustrates.

The highly increased consumption of solid wires in 1999 over 1998 by almost 35% (in USA) reflects extremely good business conditions. The changes have in addition a major impact on the manufactures of welding consumables. One needs 1.4 kg electrodes to produce the same amount of weld metal as with 1.0 solid wires meaning 40% in difference in gross weight. The consumption of cored wires in USA hides another drastic change from selfshielded to dualshielded wires out of environmental reasons. The impressing growth in consumption of cored wires in Japan is a result of

- Increase in deposition rate
- Better penetration
- Less spatter
- Efficient in positional welding

There is another explanation to the difference in use of cored wires in

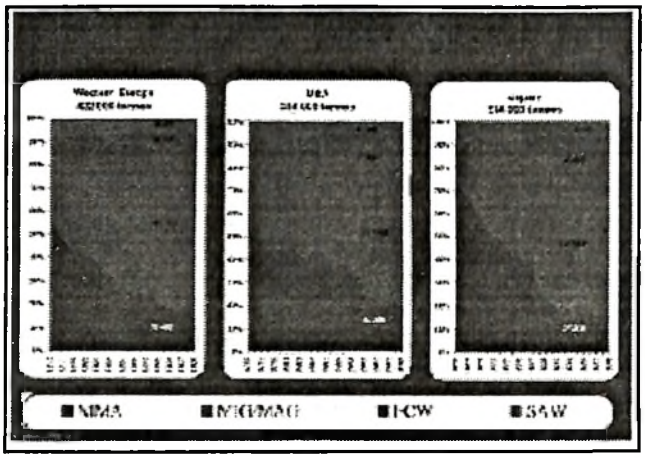

Fig 1 : Deposited weld metal 1975-1999

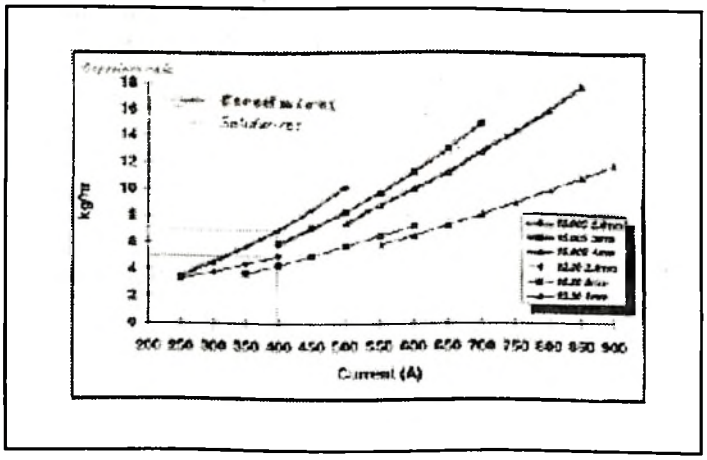

Fig 2 : (20-30)% higher deposition rate with cored wire

Europe and Japan. The price ratio between cored and solid wires is lower @ 1,5 in Japan and @ 2,5 - 3,0 in Europe. The price level for solid wires is higher in Japan.

Cored wires are increasingly used in submerged arc welding to increase the deposition rate (Fig. 2). The process offers as well higher welding speed on primed plates without causing porosity.

Deposition rate as a function of welding current with solid wire Autrod 12.20 and basic cored wire Tubrod 15.00S in Submerged Arc Welding.

There is a small patented innovation Synergic Cold Wire SAW (SCWSAW) process introduced (Fig.3). It increases the deposition rate up to 100% similar to what can be achieved with the Metal Powder SAW. In SCWSAW a cold wire is fed in synergy with the arc wire into the weld pool where it melts. This means that the arc and cold wire ratio always remains constant after a suitable wire diameter is selected.

Currently the Twin and Tandem MAG welding processes are getting high interest mainly for the higher deposition rates these are offering. There are already some installations running in production mostly in Germany and many research projects and feasibility studies are initiated. In the Twin solution the two wires have separate wire feeders but connected to one power source while in the Tandem setup each electrode has its own power source and wire feeder. In the common torch the electrodes are electrically insulated from each other (Fig. 4).

The Tandem solution has inherently greater freedom in varying the welding parameters like using different electrode diameters or mix with cored and solid wires besides the ordinary parameters for voltages, currents and travel speed. In order to reduce the spatter and the interference between the arcs, pulsing with phase shifting is introduced (Fig. 5). To get the right weld quality the arc length must be kept as short as possible to avoid undercuts. There are also indications that welding with cored wires on primed plate generates less porosity. Due to the high heat radiation and the extreme welding parameters the process is best used in mechanized application.

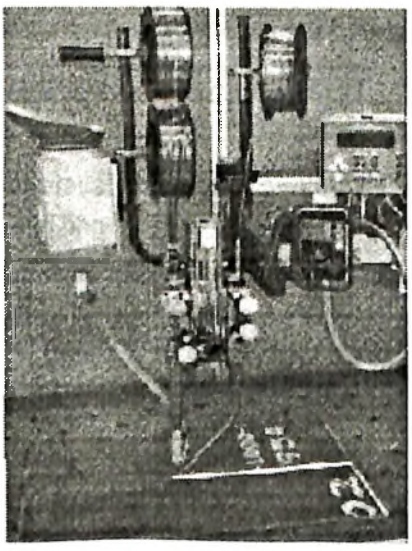

Fig.3 :
SAW twin wire set up with cold wire fed by a common electrical motor

ROBOTIZED ARC WELDING

The number of arc welding application has continuously been growing since 1975. During the last decade the markets in Europe and North America have grown larger than the Japanese one, which has suffered of poor business conditions (Fig. 6).

The volume has in the last years grown with a twodigit figure while the value has half the growth in Europe and North America. Standardized robot stations, which are similar in concept to the two station solutions introduced at the Essen exhibition 1977, are today sold like commodities. These are designed to be plugged and play with; in other words very simple to install and get running. This trend is forecasted to continue in the coming years due to demand for higher productivity, difficulties to recruit welders but also thanks to less expensive solutions.

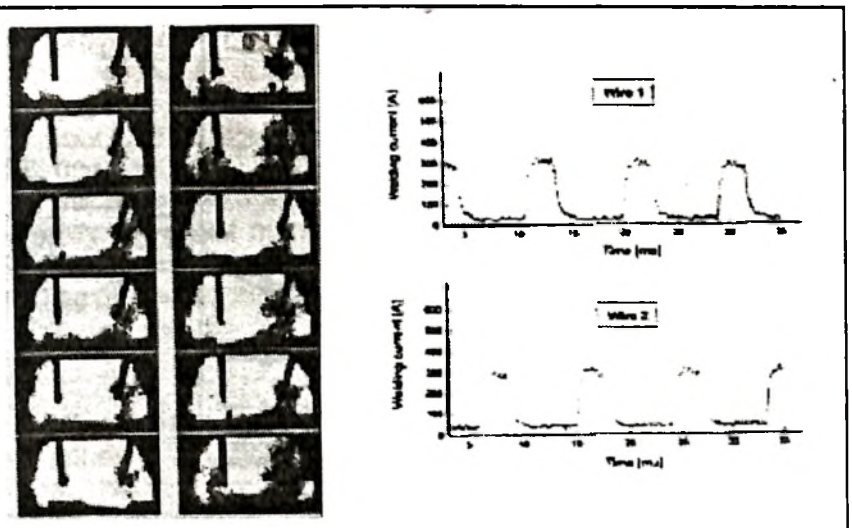

Fig. 5 : Highspeed photos on a Tandem MAG welding process with phase shifted current pulsing

Around 1980 a robot with 5 degrees of freedom plus a welding package was sold in USA for USD 60.000. Today you can buy a more powerful and versatile robot package for half the price. The robot itself has at least 6 degrees of freedom plus additionally capacity to control many additional external axis, which movements are synchronized with the robot. The welding packages contain more features and have better welding properties than before.

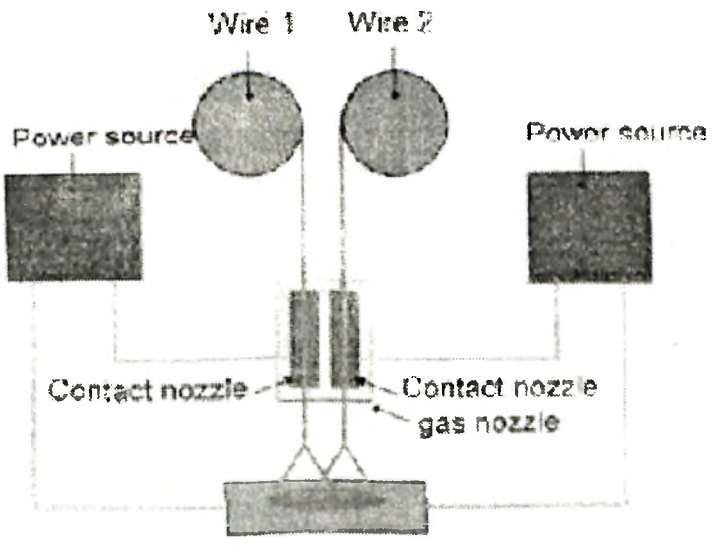

Fig. 4 : Tandem MAG welding configuration

LASER WELDING

The robots are as well very suitable for other joining processes like laser welding, thermal cutting, adhesive bonding, clinching and selfpiercing rivetting and tending in joining stations. The auto industry has currently high expectations on robotized YAG laser welding. They judge this application to have higher potential in use than the CO2-laser with a flexarm connected to a robot. It is the YAG laser with fibre-optic beam delivery, which offers the

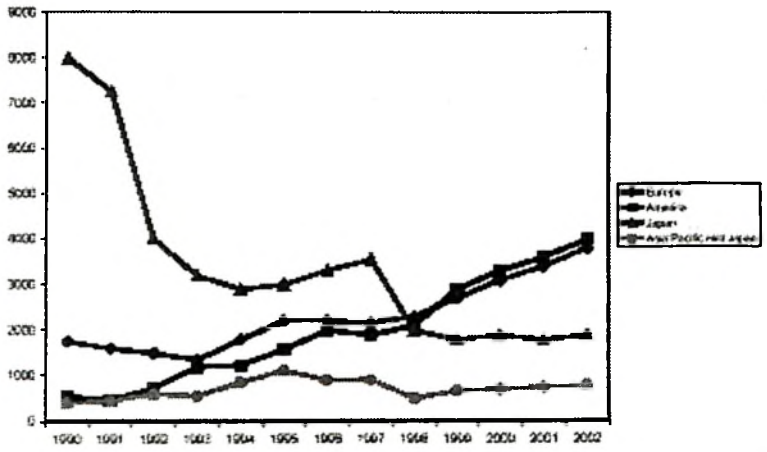

Fig. 6 : Annual sales of arc welding robots in Europe, North America, Japan and Asia excl Japan

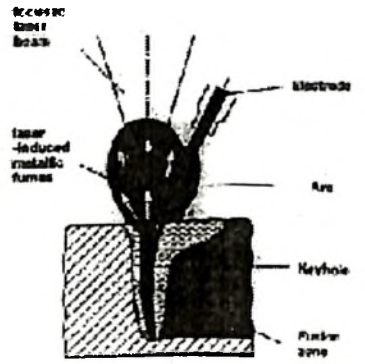

Fig. 7: Configuration for the hybrid laser MIG welding

higher flexibility. Audi is YAG laser welding 30m in the latest car A2, which has only 20m MIG welding.

Hybrid Laser MIG/MAG Welding : When it comes to plate welding of large parts, introduction of laser welding is taking longer time due to several reasons like problems with hardness in the weld metal and the requirement on the base material with low level of impurities. The closer tolerances required in joint preparation for laser welding is another obstacle to overcome. Hybrid laser MIG welding (Fig. 7) seems to become the process to resolve part of the technical problems and to reduce the investment in a laser station.

A MIG arc with 7,9 kW power combined with a 6,0 kW CO_2 laser beam compared with a pure CO_2 laser with filler metal offers (Table I).

A European shipyard has decided to invest in a hybrid laser MIG welding line for double walled panels 16x20m covering butt, fillet and stake welding. The fillet weld is throughwelded only from one side.

Table I

Parameter		Hybrid laser MIG welding	Laser welding with filler wire
Plate thickness	mm	6,0	6,0
Electrode diameter	mm	1,2	1,2
Gap width	mm	1,0	0,5
Travel speed	m/min	2,6	1,0
Wire feed rate	m/min	13,8	2,7
Power source output	kW	7,9	–
Heat input	kJ/m	321	360

We expect a technical breakthrough in the shipyard industry, when the shipyard is successful, which we will know during 2001.

There are several feasibility studies of laser welding of thick material going on for earth moving equipment, piles and pipelines, which will certainly result in implementation of the laser process in the near future.

MAGNETIC PULSE WELDING

During the last year the Magnetic Pulse Welding (Fig. 8) process is attracting a lot of interest especially in the auto and white goods industries. The process is based on a high current in short time less than 0.1 second passing through a coil creating an eddy current in the conductive workpiece. Repulsion between the two magnetic forces creates a pressure and accelerates the workpiece into a new configuration. The energy charged in

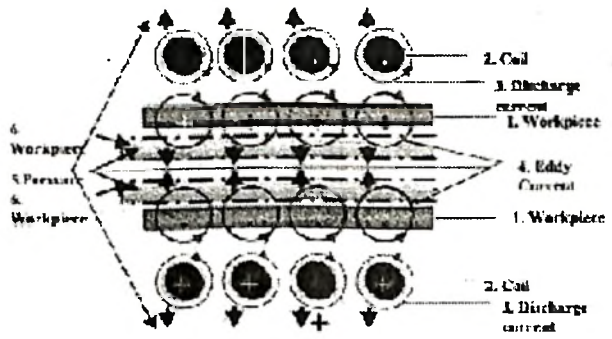

Fig. 8 : Magnetic Pulse Process

high voltage (<10 kV) capacitors is discharged through the coil with low self inductance and resistance. The peak current can reach several million amps.

The process is applicable not only for welding similar or dissimilar material but even for crimping, perforating and forming of conductive materials. It is best suited for high volumes to justify. The high cost for the tailormade coil. So far there are very few equipments put in production. One can foresee in the coming years a fast growing number of installations.

FRICTION STIR WELDING

You are certainly well updated about the FSW process, which was invented at TWI in 1991. This process has in an extremely short time become approved for very demanding applications in the aerospace (Fig. 9) and shipyard industries. ESAB was the first company in the world to deliver a production installation.

Fig. 9 FSW machine for welding fuel tanks for rockets, which are 5m in diameter and can vary in length 1-12m.

The main reasons for choosing FSW are :

- High and consistent weld quality - low defect rate 10 times lower than for arc welding
- High productivity
- Fatigue properties much better than for arc welding
- Impact values excellent
- No welding consumables
- Possible to weld Al alloys difficult to arc weld

The first installation with two welding heads running simultaneously on seatframe in Al for auto industry is in operation since a year. It will soon be followed by other applications for the same industry. The railbound industries are also carefully evaluating FSW for their applications.

MECHANICAL JOINING TECHNIQUES

The mechanical joining techniques clinching (Fig. 10) and selfpiercing

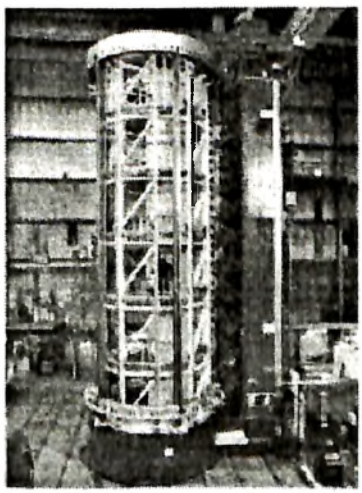

Fig. 9 :
FSW machine for welding fuel tanks for rockets, which are 5m in diameter and can vary in length 1-12m

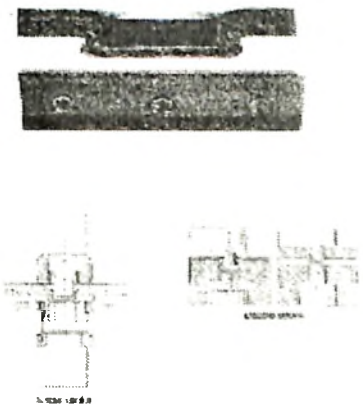

Fig.10 : Principle for two variants of clinching

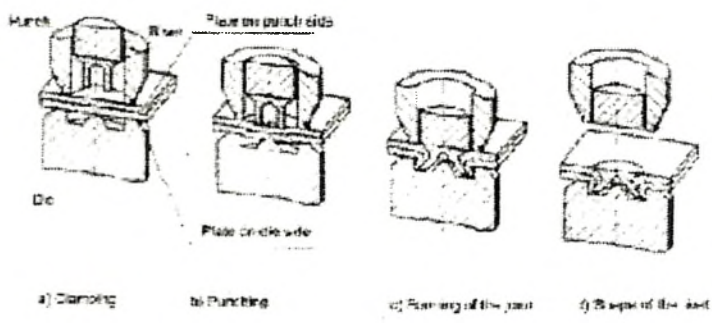

Fig.11 : Principle for selfpiercing rivetting

(Fig. 11) are fast introduced in the auto industry, which is using the most suitable processes for joining.

Some of the advantages these methods offer are

- Work with metallic and organic coating of plates without emitting fume
- Different materials can be joined
- Different material thicknesses can be joined
- Possible to make several joints simultaneously

The methods have as well disadvantages eg

Access from both sides required

- Higher forces than in spot welding required
- Positioning accuracy higher than for spot welding required
- New applications require careful evaluation
- Designers have limited knowledge about the methods
- The joint properties meaning impact, shearing and fatigue are almost close to those achieved in resistance spot welding while the corrosion properties are better with clinching. Then there is a big difference in cost (table II).

The Audi A2 is said to have up to 1800 clinched joints, which is fully understood based on the figures above.

LASER CUTTING

Laser cutting, which TWI invented but never benefitted from about 30 years ago, has today the highest growth of the most common processes oxyfuel, plasma, laser and waterjet. Cutting of thicker material up to 35mm and bevel cutting is becoming more common. The safety issues need to be carefully addressed. Furthermore, the environmental aspects with high emissions of fumes and gases get a high attention.

WORKING ENVIRONMENT

There are probably not many other crafts with so many risks associated as with welding and cutting, which ask for continuous improvement and development of an improved working environment and higher safety. We have to work relentlessly with working environmental problems like

- Electricity
- Electromagnetic fields
- UV, IR and visible light radiation
- Thermal radiation
- Welding and cutting fumes and gases
- Fire and spatter
- Ergonomics
- Machine safety
- Laser safety

Table II

Method and material	Relative cost
Clinching of unalloyed steel or Al	100
Spotwelding of unalloyed steel	165
Spotwelding of unalloyed steel with 10 µm Zn	220
Spotwelding of unalloyed steel with 20 µm Zn	260
Spotwelding of Al	370

SUSTAINABLE ENVIRONMENT

In addition to all other commitments in one's duties the sustainability has become another aspect to consider in our professions and privately. We are at the same time facing increasing legal requirements asking for stricter control of the environmental issues. In the welding and cutting society we are just in the infancy position. We have to start working if not already made with

- Improving the energy efficiency
- Reducing the energy consumption
- Using renewable energy sources
- Reducing waste
- Elimination of non-products eg packaging
- Labelling items in products to simplify a safe recycling and disposal of it
- Starting reusing items in scrapped products
- Reducing the environmental impacts of products by applying LCA (Life Cycle Assessment)
- Introducing DFE (Design For Environment)

In order to get the proper things done we have to start measuring, monitoring, screening and comparing and benchmarking the environmental factors. It is a common management approach to be applied also in this field.

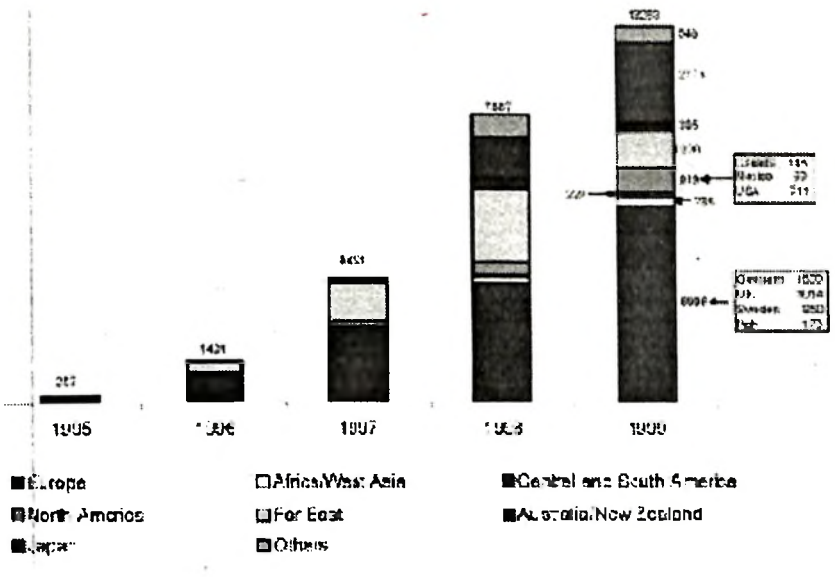

Fig.12 : ISO 14001 certifications in the world

A necessary platform for an environmental program i s an EMS (Environmental Management System) according to ISO 14001 or EMAS (European Union Eco-Audit Scheme). Some major companies eg GM, Ford and ABB are already asking their vendors to implement EMS to remain a subsupplier. This will certainly result in a high growth of certified companies (Fig. 12). There are several sets of tools to be introduced to comply with an EMS.

Environmental Auditing

ISO 14010 Guidelines for environmental auditing – General principles

ISO 14011/1 Guidelines for environmental auditing – Auditing of environmental management system

ISO 14012 Guidelines for environmental auditing – Qualification criteria for environmental auditors

Environmental Labelling

ISO 14020 Environmental labels and declarations – General principles

ISO 14021 Environmental labels and declarations – Self-declared environmental claims (TypeÊII Environmental labelling)

ISO 14024 Environmental labels and declarations – (TypeÊI Environmental labelling – Principles and procedures)

Environmental Performance Evaluation

ISO 14031 Environmental management – Environmental

performance evaluation – Guidelines

ISO 14032 Environmental management – Environmental performance evaluation – Case studies illustrating the use of ISO 14031

Life Cycle Assessment

ISO 14040 Environmental management – Life cycle assessment – Principle and framework

ISO 14041 Environmental management – Life cycle assessment – Goal and scope definition and inventory analysis

ISO 14042 Environmental management – Life cycle assessment – Life cycle impact assessment

ISO 14043 Environmental management – Life cycle assessment – Life cycle interpretation

A prerequisite for a success with such an environmental mission is the commitment involvement by the management but also all employees. Another key element in EMS is the training of all employees.

Of all different programs I have experienced during more than 35 years in this business the environmental program has caught the highest interest and engagement. With the aligned resources we monitored a continuous improvement (Fig. 13) in accordance with ISO4001.

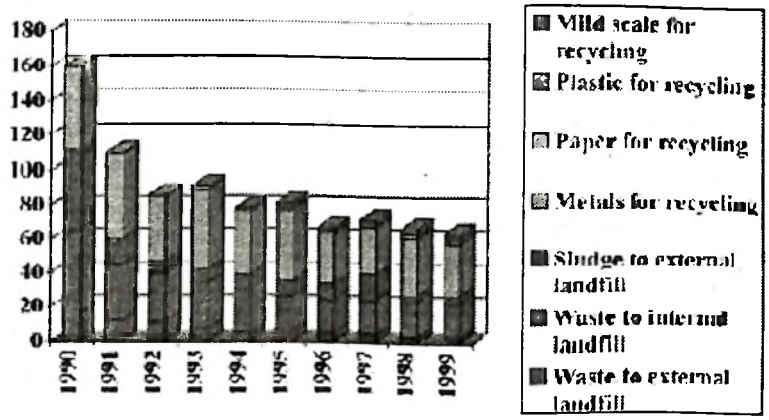

Fig.13 : Total waste kg/ton produced electrodes

We in joining and cutting world have not or have started very slowly working for sustainability. It is now high time to take off with an environmental program if we have not already made it.

CONCLUSION

This broad techno economic survey of the joining and cutting processes and environmental issues shows a continuously improvement of existing processes combined with emerging joining processes. To be competitive in one's business and to be informed about the progresses one needs to be regularly updated about these matters. The environmental issues must also get higher priority on our agendas.

REFERENCES

1. Mohammed Naeem, YAG laser welding of thin sheet by Lumonics Ltd, UK, Pages 6-10, Welding & Fabrication, June 2000
2. Prof Dr-Ing U Dilthey, Dipl-Ing A Wieschemann, Prospects by Combining and Coupling Laser Beam and Arc Welding Processesby ISF-Welding Institute, Aachen University, Germany IIW Document XII-1565-99M
3. Victor Shribman, Yuri Livshitz and Oren Gafri, Magnetic Pulse Solid State Welding by IIW Document XII-1636-00
4. Say Audi to the New Space Frame Page 11-14, Welding & Fabrication, March 2000

■