Advancement of Welding Technology In the World

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Synopsis

The welding technology must fit to the purpose of each construction. This includes a careful understanding of demands, the adapted materials and their behaviour subjected to welding. The manufacturing is very essential too.

The education of welding and control personnel will change. The integration of robotics, sensing and automation in the production makes the role of personnel and their responsibility very much different. The paper tries to give the state of the art and an estimation for this and possibly the next decade(Fig. 1).

Steels (Materials)

Coated steels have been for decades and have a wide usage. However, despite many attempts to introduce them into fabricated sheet metal constructions such as cars and containers (in order to improve corrosion resistance), their use has been very restricted. The problems have been disruption of the welding process and contamination of the welded joint with subsequent degradation of properties.

Modern higher strength steels in sheet form are more recent, say 15-20 years, and were introduced with the objective of improved performance and economy (weight saving). Again, these steels have found only limited application due to welding and joining difficulties plus problems in maintaining properties in the welded joint.

Thus the application of both coated and higher strength sheet steels has been long delayed despite their obvious attractions and the interest of companies such as automobile manufacturers. The technical and scientific reasons for the problems are different but the common difficulty is welding. Although many studies of welding both groups of steels have been made they have been technological and piecemeal, resulting in relatively disappointing achievements.

With coated steels, the problems have been disruption of the welding arc due to vaporised coatings leading to surface defects and reduction of weld properties. Research has led to successful results for some thinner coatings but thers is a need to weld rather heavier coatings.

The difficulties in welding the modern higher strength steels result from the different mechanism used to obtain the high strength. Conventional steels use metallurgical behaviour under arc welding processes is well understood (Fig.2).

However, attempts to increase strength by additional carbon and/or alloying additions lead to embrittlement and cracking problems in the development has been terminated. The alternative approach has been to apply thermo-mechanical treatments with "lean" steels with low carbon and alloy contents. The metallurgy involves precipitation hardening, control of dislocation density and the introduction of a limited amount of strain hardening by the combination of controlled composition, heating and cooling cycles, and rolling. This approach has been very successful for thicker steel plates, above 8 mm, and arc welding procedures have been developed that give excellent joint performance.

A considerable number of published papers exist on the fusion welding of modern HSLA steels, though these mainly refer to heavier section material from 10-40 mm thickness. Processes used have included most conventional arc welding processes, electron beam and laser welding. Plasma welding has attracted far less attention. Considerable success in achieving satisfactory welds have been reported although alarming reductions in strength, ductility and toughness can sometimes be noted on careful study of the results, especially with thin sections.

There is a far fewer papers reporting the results of fusion welding trials on sheet HSLA steel, from 0.5 to 6.0 mm thickness. Results tend to be less satisfactory than for thicker steels with reductions in strength, toughness and fatigue behaviour. With arc welding the weld metal strength can be maintained, sometimes at the expense of ductility and fracture toughness but HAZ strength can be reduced. Fatigue strength can be no better than that of conventional sheet steel welds although there are some promising unpublished results indicating improved fatigue strength. High energy density processes such as laser, electron beam, and possibly plasma, welding lead to narrow rapidly cooled welds which can have low ductility, notch toughness and fatigue strength. Plasma welding gives the least severe thermal cycle of these high energy density processes and may prove a useful compromise between equally detrimental rapid and slow thermal cycles.

Design and Calculation

With welded thinner sheet material problems still exist. Static strength and ductility is less of a problem than rigidity, stiffness and fatigue behaviour. Toughness can also be reduced in various parts of the welded joint whilst the mis-matching of weld metal, HAZ and parent metal can lead to premature failure, Fig. 3.

The difficulties lie basically in the severe thermal cycles associated with welding. The weld metal experience melting and generally rapid solidification along with dilution from any added filler metal and gas-metal reactions in a turbulent weld pool. The adjacent HAZ consists of a range of adjacent regions which have been subjected to different thermal cycles which can drastically influence the submicroscopic structure of the original parent steel. The result can be unacceptably LBZ (local brittle zones) low strength, ductility, toughness and fatigue behaviour(Fig. 4).

Design for fatigue and calculation of fatigue will become essential in the future(Fig. 5).

Other important aspects is the stiffiness(Fig. 6).

Processes

The primary incentive for welding process development is the need to improve the total cost effectiveness of joining operations on manufacturing industry. However, other factors may influence the requirement for new processes. Recently, concern over the safety of the welding environment and the potential shortage of skilled technicians and operators in many countries have become important considerations.

Many of the traditional welding techniques are regarded as costly and hazardous and it is possible to improve both of these aspects signficantly (Fig. 7).

Areas of general development seem to be :

- increased deposition rate;
- reduced cycle time;
- improved process control;
- reduced repair rates;
- reduced weld size;
- reduced joint preparation time;
- improved operating factor;
- reduction in post-weld operations;
- reduction in potential safety hazards;
- removal of the operator from hazardous area;
- simplified equipment setting.

Manufacturing

The use of single-shot processes like resistance spot welding and continuous processes such as GMAW enable increased use to be made of automation(Fig. 8).

Interaction of parameters may influence the tolerance.

For example, thickness and positioning - tolerances are appeared in Fig. 9.

Concepts of adapting of modern electronics in workshop practics are shownin Fig. 10.

QUESTION : HOW ROBUST AND RELIABLE ARE THE AVAILABLE SYSTEMS IN THE PRODUCTION ?

ANSWER : DEVELOPMENT NECESSARY !

Education

Increased demands make a modification of the education of all categories of welding personnel very essential.

- inspection & Control
- sensors - robotic's manipulation
- welding metallurgy
- thermo-metallurgical processing
- design for fatigue
- reproducibility of procedures
- tutorials and practical studies

The role of the personnel is changing and interfere of personnel in the actual production is getting less and less possible or appropriate.

Conclusion

Study of relevant literature and discussions with industry emphasis, that research and development of welding has been piecemeal and empirical. If the problems are to be solved a methodical, soundly based programme is needed involving study of the effect of material impurities, shielding gas composition and welding parameters. It is also essential to determine operational envelopes for welding specific materials thicknesses and joint designs for subsequent transfer to automatic/robotic welding stations.

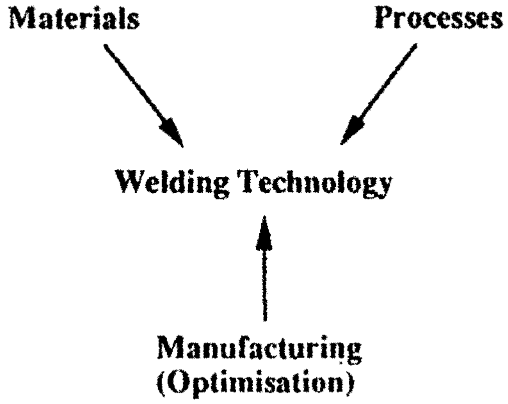
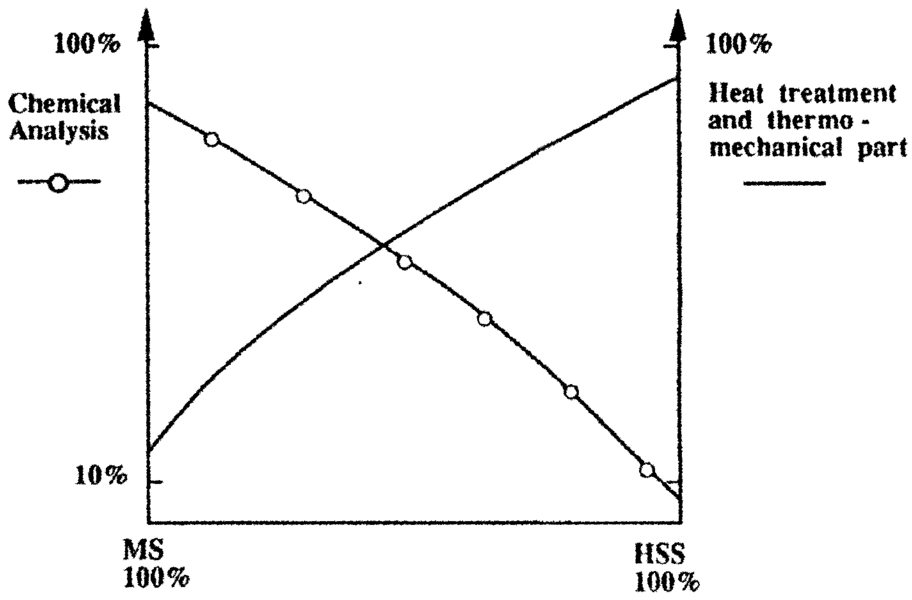


Fig. 1. Welding technology shall be in settlement with materials, process and manufacturing



'g. 2 Strengthening mechanism in conventional (MS) and high strength steels (HSS)

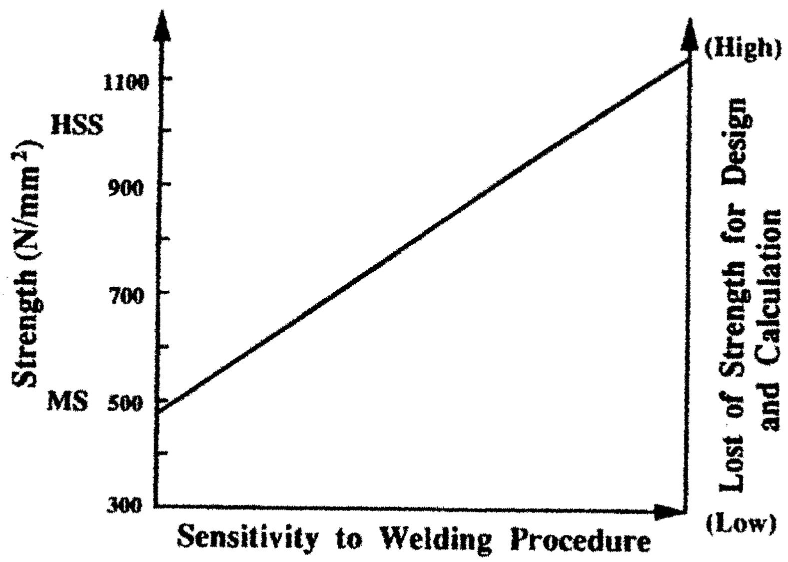
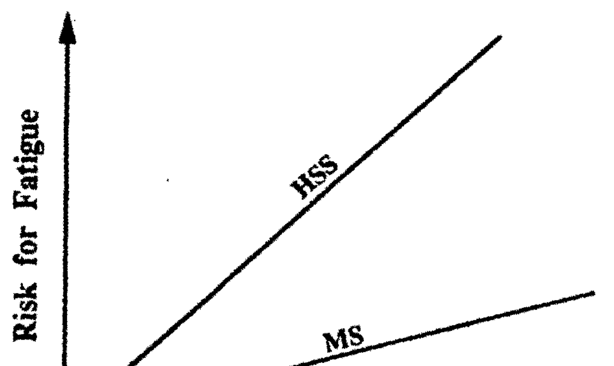


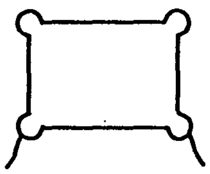
Fig. 3. Static strength - Dynamic values (Fatigue)



' Sensitivity to procedure changes in HSS and MS

Shell of Gyratory Crusher

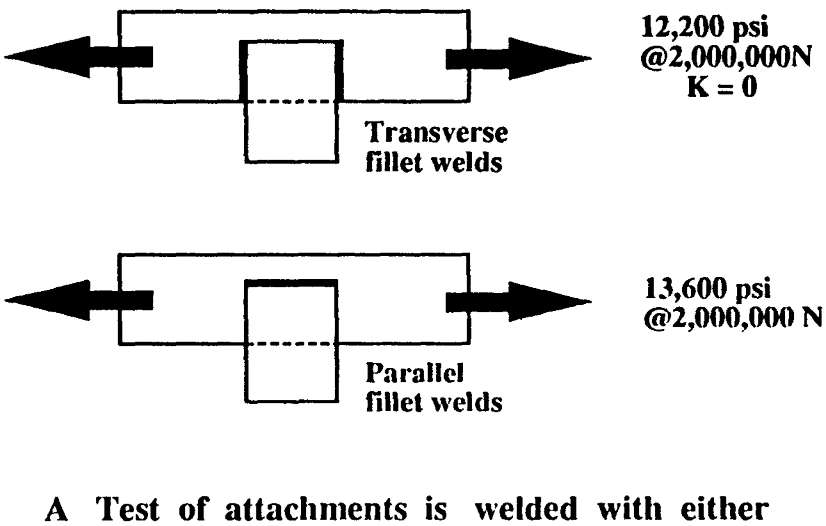
O single drilled hole did not crack



rectangular hole with same round corners did crack

apparently more movement around this hole

A Circular housing of a gyratory crusher



A Test of attachments is welded with either transverse or parallel fillet welds.

Fig. 5 Design and Calculation
Based widely and mainly on static strength of steel
Future : Necessary to design for fatigue

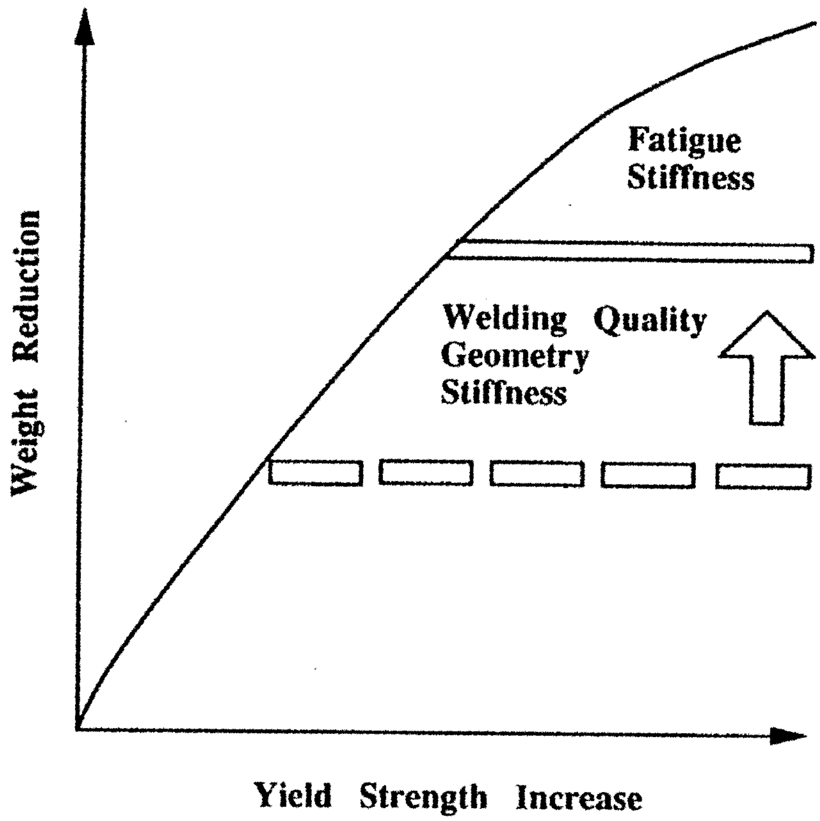


Fig. 6 The use of high strength steel demands besides fatigue.
Other changes :
Example : Stiffness

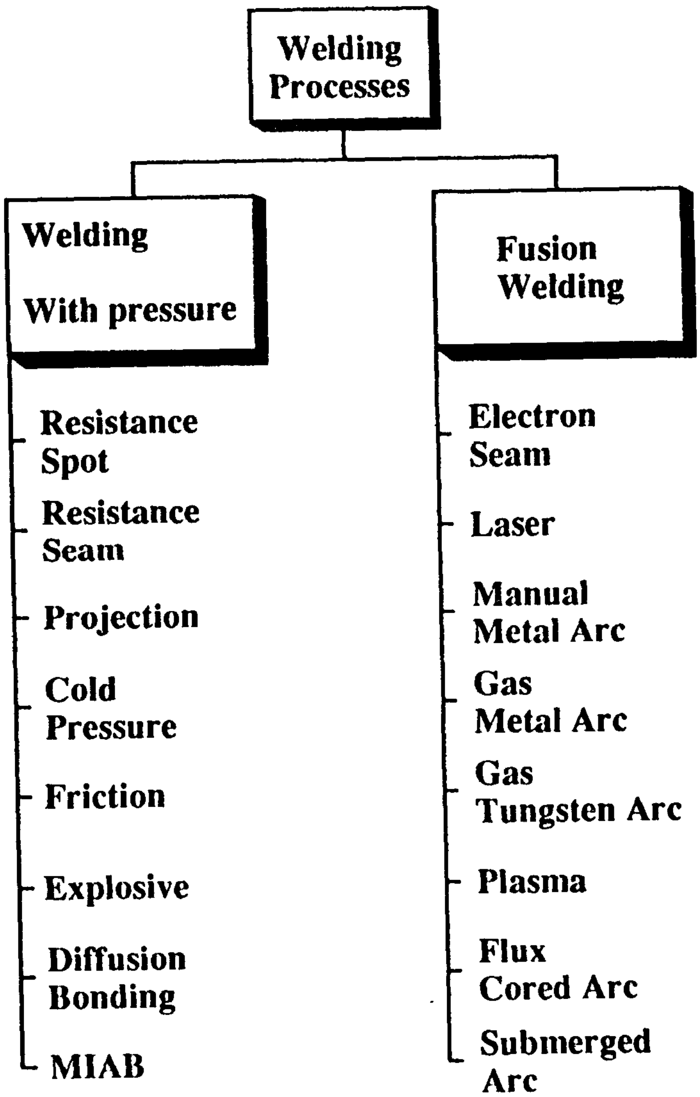


Fig. 7. Important welding processes

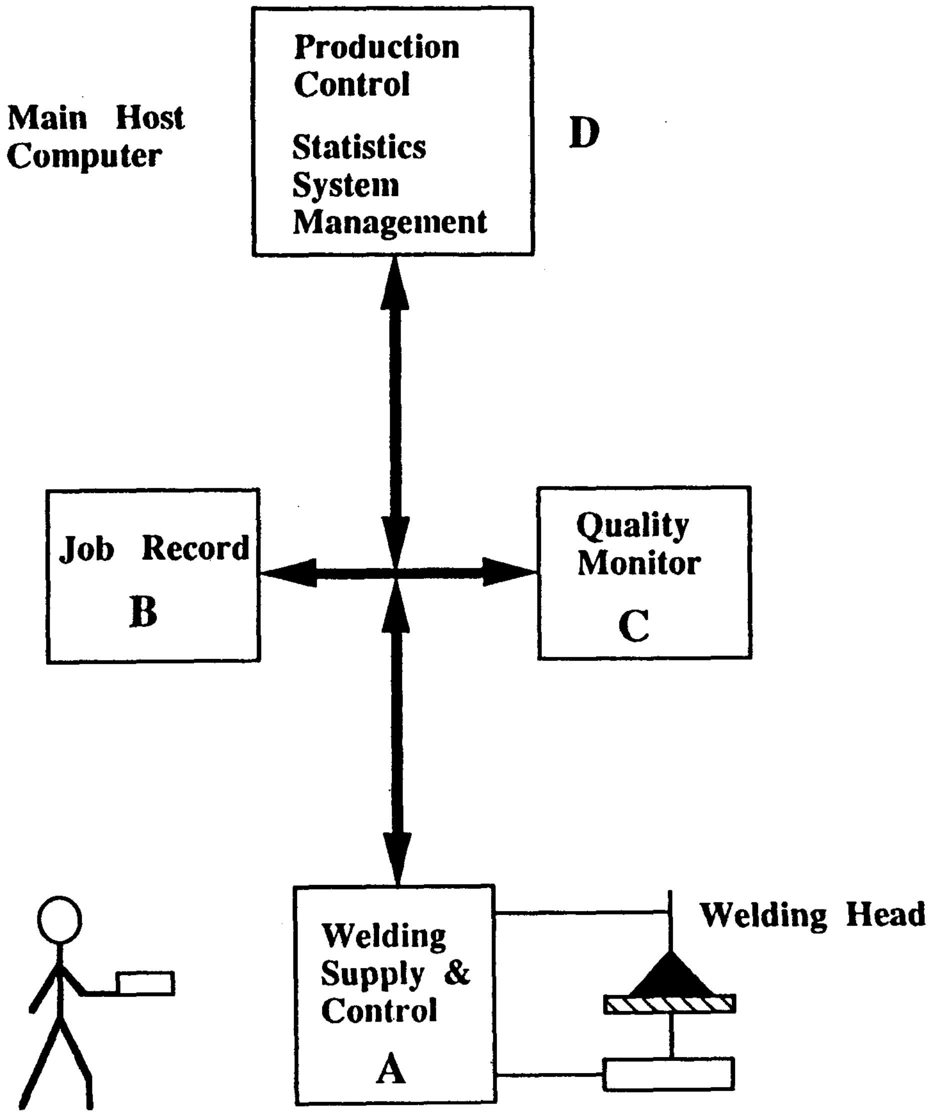


Fig. 8 Integrated welding system. Operator selects job at A. Computer in the welding power supply sets pararmeters and supplies information. The job record is stored at B. On - line monitoring system C checks quality. Host computer D controls the system and provides a management report.

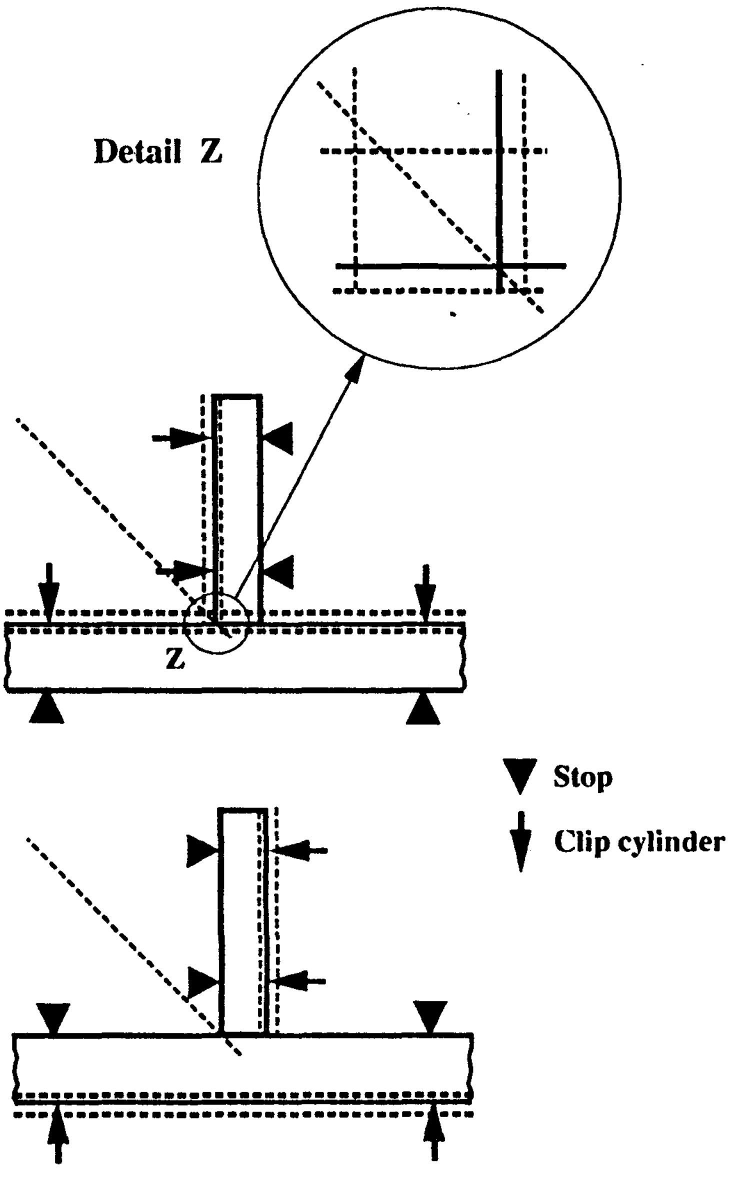


Fig. 9 Positioning for welding :
Variation of thickness influences
the wire positioning

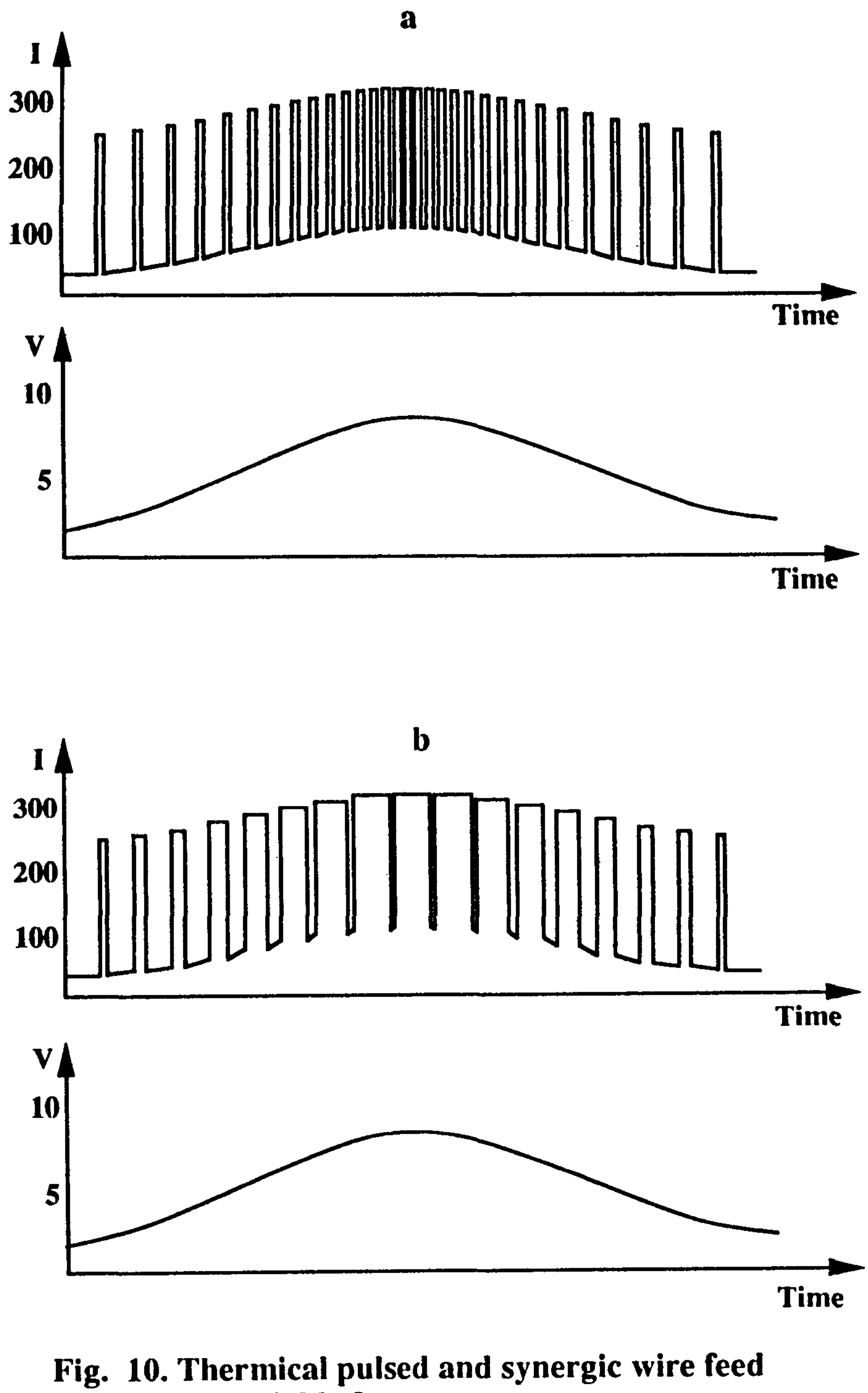


Fig. 10. Thermical pulsed and synergic wire feed
a. Variable frequency
b. Variable pulsing time