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Laser processing activities in Finland – technological and educational view

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1. Introduction

Finnish laser R&D is started in 1985, when the first large laser project was started in Lappeenranta University of Technology. This was the pioneering on laser welding and surface treatment in Finland. Since that numerous projects on different fields of laser technology have been executed. In addition some other later activities in universities and colleges have been started. The present developments and activities are mainly concentrated in laser welding (autogenous, filler metal and hybrid welding), laser cutting and laser micro processing.

The first high-power laser installation in Finland was a flat laser cutting system at Tammerneon Oy (Tampere) in 1981. Soon after, about ten same kind of systems were bought for sheet metal cutting.

Since then a rapid growth of laser processing systems has continued and it shows no signs of slowing down. The total number of systems is about 400 CO_2 lasers and 150 Nd:YAG lasers, used mainly for cutting and marking, Fig. 1.

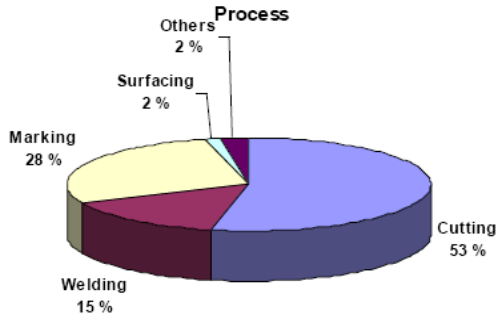

Fig. 1 The industrial laser systems in Finland

Recently seven diode lasers and a few disk and fiber lasers have been installed. The most applications are on laser cutting of steels, there are some interesting applications, e.g. laser welding of sandwich panels, laser cutting of glass tube monitors and laser welding of catalytic converters. These and some more applications shortly described below.

Educational activities were started just after 1985. Currently education is executed in basic engineering and doctoral levels, as well as in continuing education of laser processing experts.

2. Industrial activity

A major portion of Finnish laser industrial activity is in laser cutting with a minor role for laser welding. The main reason for this is the strong role of the heavy metal industry, where companies process in small lot numbers. Finland does not have many companies with long production runs such as the auto industry, where laser welding was typically first applied in many countries. However, recently a growing interest to laser and hybrid laser welding is seen. About ten companies have currently laser welding in their production.

The heavy metal industry was started because Finland needed to pay back World War II reparations to the Soviet Union, so they agreed to pay with heavy metal products. So many large companies were established to produce heavy machines, lorries, trains, and so on. The last portion of these reparations was paid in late 1950's, but the industry remained and started to produce all kinds of heavy metal products such as pulp and paper machines, luxury ships, cranes, elevators and power stations.

In the late 1990's the number of laser welding applications started to grow. Many subcontractors established facilities such as HT Lasertekniikka Oy (Keuruu, now in 13 locations), High Metals Production Oy (Vantaa), Laserle Oy (Helsinki) and LaserPlus Oy (Riihimäki) applied it in several cases. Veslatec Oy (Vaasa) is a subcontractor in fine mechanics offering precision and microwelding, as well as cutting and drilling, mainly using Nd:YAG pulsed laser technology.

Some companies apply laser welding to their own products. Outokumpu Oyj has three laser welding systems in Finland. One is in their RAP sheet processing line (Tornio), welding coils together and two systems are in their Outokumpu Stainless Tubular Products Oy (Pietarsaari) plant for welding tubing. Kennotech Oy and Rautaruukki Oyj weld sandwich panels in their factories in Hämeenlinna and Uusikaupunki, respectively. STX Finland Oy (Turku) has a system for a sheet line, which will use a 6 kW fiber laser in a hybrid welding application. Laser cladding is a subcontracting business of Kokkola LCC (Kokkola). Here the work is concentrated on repair welding for power station applications, but the applications are widening into other sectors, Fig. 2.

Ecocat Oy (Vihtavuori) welds catalytic converters using a diode laser, Fig. 3**.** Catalytic converters are welded with diode laser at a power of 3 kW and speed about 2,5 m/min, focal length 100 mm, focus on the surface. The weld penetration needed is 1.5 mm. The mechanical tests showed 10-20 times longer durability than conventional brazed converters. Emissions from this EcoXcell showed to be about 28% better than conventional converters [1].

One of the most specific Finnish applications is from Proventia Automation Oy (Forssa) which cuts television monitors for waste purposes a seen in Fig. 4. This company, has a world-wide patent and produces the machines forcutting a more valuable face surface apart from the lead-containing tube. The workpiece is placed on fixture, installed into rotating table, such that the thick glass of the pane is downwards, and the funnel upwards. The CR-tube is rotated after a side is laser treated, continued by treating of the next side. This way the whole tube is treated. A groove, typically 1-6 mm in depth and about 2 mm wide is formed. When the cutting line is produced around the tube the thermal tensions caused by heating with laser from a narrow zone breaks the tube [2].

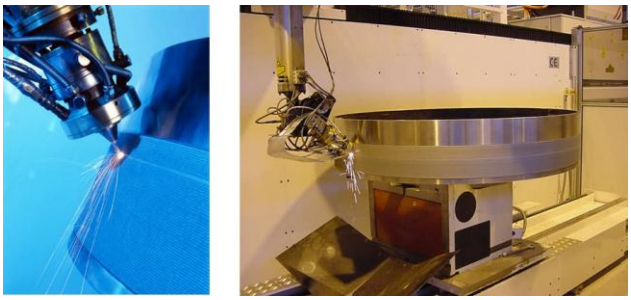

Fig. 2 Laser cladding (courtesy of Kokkola LCC)

Fig. 3 Diode laser welding of a catalytic converter

Fig. 4 Laser cutting of television monitor

Apart from laser welding and surface treatment, laser cutting is a still increasing the business of subcontractors. About 400 systems for laser cutting are working for this purpose and the largest company is HT Lasertekniikka Oy with 12 locations and more than 20 systems.

3. Research and development in laser processing in Finland

Research and education on laser materials processing is concentrated in two universities, Lappeenranta and Tampere Universities of Technology.

At Lappeenranta Laser Processing Centre, which is a cooperative facility with Lappeenranta University of Technology and VTT, a national research centre, there are 25 people working in R&D and education, Fig. 5. The main research fields are in laser and hybrid welding, surface treatment, laser welding of plastics, microlaser processing and paper processing. The group is very active in publishing and servicing the industry. In addition, the university has undergraduate and a graduate student programs in laser processing and arranges continuing education programs and seminars. They have more about 15 laser systems in the facility. In Tampere, 10 people are working on laser processing, concentrating on surface heat treatment. In addition, Tampere is also strong in optics and has several optics companies started from its Optical Research Centre. University of Oulu has an installation in Nivala with two disc laser stations.

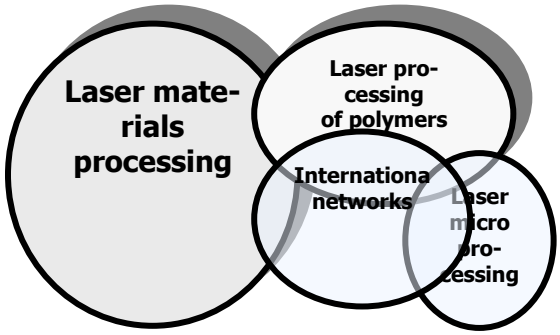

Fig. 5 R&D fields of Lappeenranta Laser Processing Centre in Lappeenranta, Finland

In addition, several Applied Universities and schools have started their education and service for the industry in laser and hybrid laser welding and cutting. These are located in Kokkola, Keuruu, Laitila, Turku, Lieksa, Riihimäki, Tornio and Raahe.

Laser welding including filler metal and hybrid laser welding, has been a major research activity for 20 years in Lappeenranta, e.g. Fig. 6. Recently the research has concentrated also on new fields, adaptive laser welding and aluminium laser welding applications.

One of the most specific R&D fields of Lappeenranta Laser Processing Centre is thick section multipass welding, the research of which is aiming to ITER fusion reactor applications, Fig. 7. In includes large and thorough investigation of filler metal Nd:YAG , Nd:YAG-MIG hybrid and electron beam welding of thick stainless steels, up to 60 mm thickness.

Ten recent years LLPC is also concentrated in some fields of micro processing. These include laser drilling, laser polishing and laser structuring, Fig. 8. Because of

a strong field of Finnish industry, electronic sector, also polymer welding has been a strong part of the activity, Fig. 9.

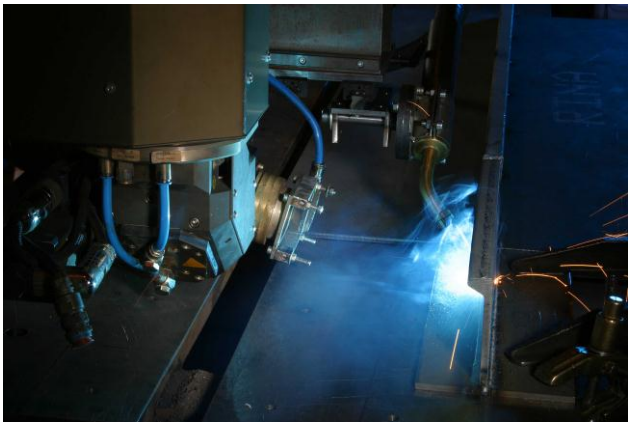

Fig. 6 Hybrid laser welding of a structural steel case

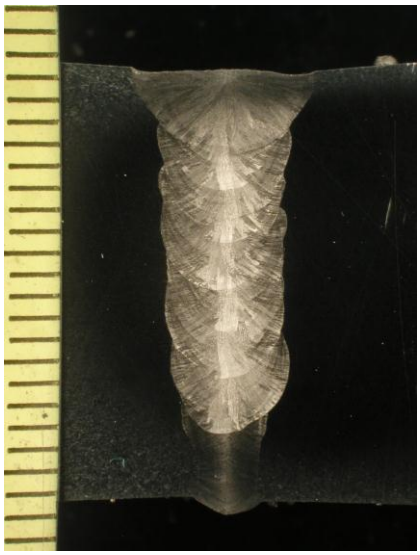

Fig. 7 Hybrid Nd:YAG laser multi-pass weld. Thickness 20 mm, AISI316 LN steel, 11 passes, welding speed in root pass 1,3 m/min, filling passes 1 m/min, laser power 3 kW, wire speed varying 9-11 m/min

Fig. 8 Laser polishing of metal

In 1988 it was established a Beam Processing Club under Finnish Welding Society to increase the interest of laser and electron beam processing. It arranges seminars and happenings for specialists to meet together. Recently in 2005 it was also established a Laser Forum, which is a member society under Finnish Welding Society for interested companies to meet and update the know-how with research facilities in the country.

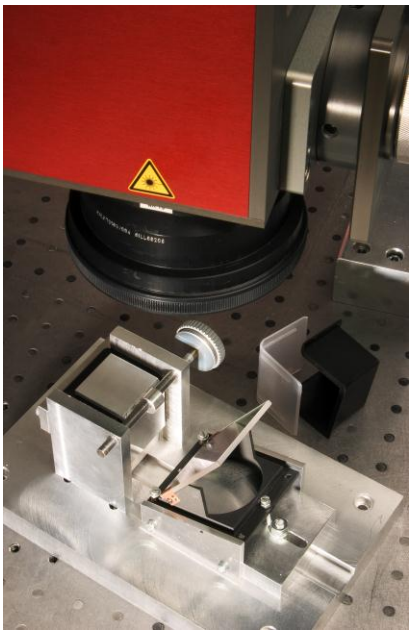

Fig. 9 3D polymer welding for mass production

The Laser Forum meets several times a year to update the knowledge and visit to companies working in the field laser processing. On the other hand the efficiency of laser and other high technology is considered in Finnish industry and compared with other countries [3]. The benchmarking as a popular method has been used to achieve this aim.

4. Educational activities in laser processing

Finland has been very active in organizing different kinds of education concerning laser processing. First seminars started in Lappeenranta in the middle of 1980's with name "Laser Welded Top Product". These seminars were an effective way in delivering the state of the information about laser processing to Finnish industry. Since that traditionally almost every year a seminar is arranged under a current topic of laser welding.

First international conference on laser processing was held in 1991, when 3rd NOLAMP, Nordic Conference in Laser Materials Processing, took place in Lappeenranta. Since that time several conferences have been organized (1999 7th NOLAMP, 1999 1st JOIN, 2003 2nd JOIN, 2007 11th NOLAMP and 2007 3rd JOIN).

The international co-operation in education stepped on a new level when together with The European Welding Federation "The Laser Expert"-course was developed.

The course is concentrating in laser welding, but also other fields of laser materials processing shall be taught. A new EWF guideline on laser welding personnel is designed and recently accepted under the chairman from Lappeenranta University of Technology.

On the Masters level, the education in laser processing started in Lappeenranta University of Technology

in 1987 and more than 150 masters have been graduated. The first doctoral thesis in laser processing technology was done in Lappeenranta University of Technology, in 1991, when Dr. Sun Zeng defended his thesis about laser welding. Six doctoral theses have been done in the laser materials processing in LUT since that, now average of every other year.

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LAZERIŲ TECHNOLOGINIS IR EDUKACINIS PANAUDOJIMAS SUOMIJOJE

R e z i u m ė

Straipsnyje pateikiama dabartinė lazerių naudojimo Suomijoje būklė. Jie naudojami pramonėje, mokslinuose tyrimuose, taikomi mokymo procese. Tyrimuose lazerius pradėta naudoti ir diegti 1985 metais Lappennantos technologijos universitete. Pramonėje lazeriai daugiausia naudojami lazeriniam pjovimui, mažiau – lazeriniam suvirinimui. Nuo 1990 metų lazerinis suvirimas ėmė populiarėti ir daugelis subrangovų pasinaudojo šia galimybe.

Lazerinio medžiagų apdirbimo tyrimai ir švietimas yra sukoncentruoti dviejuose universitetuose – Lappeerantos ir Tamperės technologijos Universitetuose. Pagrindinės tyrimo sritys yra lazerinis ir hibridinis suvirinimas, paviršiaus apdirbimas, lazerinis plastmasių suvirinimas, mikrolazerinis apdirbimas ir popieriaus apdirbimas. Be to, keletas taikomųjų mokslų universitetų (koledžų) ir mokyklų pradėjo mokyti pramoninio lazerinio ir hibridinio lazerinio suvirinimo bei pjovimo ir techninės priežiūros. Lazerinio apdirbimo podiplominis studijų aktyvumas Suomijoje yra išplitęs visuose lygiuose – nuo lazerio operatoriaus iki tarptautinio lazerių eksperto. Suomija yra viena iš aktyviausiai lazerinio medžiagų apdirbimo tęstinį mokymą organizuojančių šalių pasaulyje.

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LASER PROCESSING ACTIVITIES IN FINLAND – TECHNOLOGICAL AND EDUCATIONAL VIEW

S u m m a r y

This paper presents the current situation of laser processing technology in Finland; industrial activities, research and development and education. The Finnish laser processing R&D started in 1985 in Lappeenranta University of Technology. The major portion of industrial laser applications are laser cutting and laser welding has a minor role. In the late 1990's the number of laser welding applications started to grow and many subcontractors established facilities.

Research and education on laser materials processing is concentrated in two universities, Lappeenranta and Tampere Universities of Technology.

The main research fields are in laser and hybrid welding, surface treatment, laser welding of plastics, micro laser processing and paper processing. In addition, several Applied Universities and schools have started their education and service for the industry in laser and hybrid laser welding and cutting.

The postgraduate educational activities in laser processing in Finland are comprehensive in all levels from laser operators to international laser experts. Finland has been the one of the most active countries in the world in organizing continuing education in laser material processing.

Keywords: laser processing, Finland, technological and educational view.

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