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Introduction to finnish laser processing activity

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Abstract

This paper presents the current situation of laser processing technology in Finland; industrial activities, research, development and education. The Finnish laser processing R&D started in 1985 in Lappeenranta University of Technology. Major portion of industrial laser applications are laser cutting and laser welding has 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 several universities, Lappeenranta and Tampere Universities of Technology, Aalto University and the research facility VTT Technical Research Centre of Finland Ltd. The main research fields are in laser and hybrid welding, surface treatment, laser welding of plastics, micro laser processing, paper processing and recently additive manufacturing. 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.

Keywords: Finnish laser processing; industrial applications

1. Introduction

Finnish laser R & D is started in 1985, when first large laser project was started in Lappeenranta University of Technology (LUT). This was the pioneering work on laser welding and surface treatment in Finland. Since that numerous projects on different fields of laser technology have been executed in LUT, VTT, Tampere University of Technology and Aalto University. 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, laser micro processing and recently especially in additive manufacturing.

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 close to 1000, used mainly for cutting and marking, but some tens also on laser and hybrid welding, Fig. 1.

Most of lasers in use are still carbon dioxide lasers, but the recent investments are fiber or disc lasers. In addition, more than ten diode lasers are used, e.g. on laser cladding or sheet metal welding.

Educational activities were started just after 1985. Currently education is executed in bachelor, master and doctoral levels in most technical universities, as well as continuing education of laser processing experts. The education has been largest in LUT.

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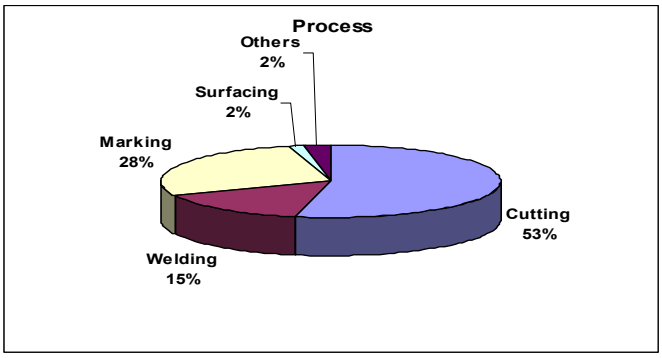

Fig. 1. The industrial laser systems in Finland.

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. Only Valmet Automotive currently produces Mercedes Benz A-type cars and has several laser welding units in their production (Industrial Laser Solutions, 2012). However, recently a growing interest to laser and hybrid laser welding is seen. About 20 companies have currently laser or hybrid 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 it 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 1950s, 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 9 locations), High Metals Production Oy (Vantaa), Laserle Oy (Helsinki) and Rautatyö Kröger (Jyväskylä) applied it in several cases. Veslatec Oy (Vaasa) is a subcontractor in fine mechanics offering precision and micro welding, as well as cutting and drilling, mainly using fiber and Nd:YAG pulsed laser technology. Recently there has been some more subcontactors as Velas Oy or Veldo Oy.

Some companies apply laser welding to their own products. Outokumpu Oyj has several laser welding systems in Finland. One is in their RAP sheet processing line (Tornio), welding coils together and another is in their Outokumpu Stainless Tubular Products Oy (Pietarsaari) plant for welding tubing. Kennotech Oy laser welds sandwich panels in a new factory in Hämeenlinna. Mayer Turku Oy (Turku) has a system for a sheet line, which will use a 6 kW fiber laser in a hybrid welding application. In addition e.g. Metso has two laser installations. Laser cladding is a subcontracting business at Kokkola LCC (Kokkola). They have two large diode laser based cladding stations. Here the work started on repair welding for power station applications, but the applications have widened also 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 con-verters. Emissions from this EcoXcell showed to be about 28 % better than conventional converters (Salminen et al., 2002).

One of the most specific Finnish applications is from Proventia Automation Oy (Forssa) which cuts television monitors for waste purposes. This company, has a world-wide patent and produces the machines for cutting 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 (Salminen et al, 2004).

Apart from laser welding and surface treatment, laser cutting is a still increasing the business of subcontractors. About 600 systems for laser cutting are working for this purpose and the largest company is HT Lasertekniikka Oy with 8 locations and more than 20 systems.

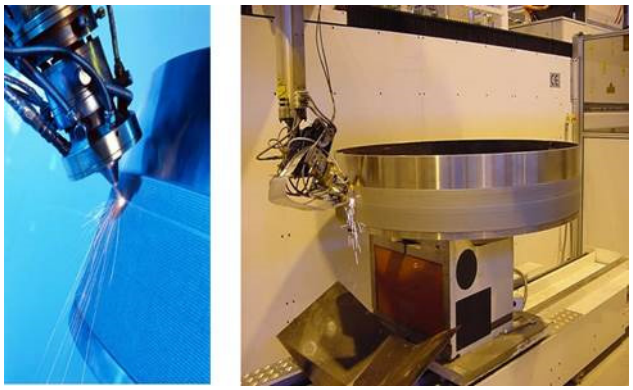

Fig. 2. Laser cladding (courtesy of Kokkola LCC).

Recent trend has made a lot of interest for additive manufacturing. There are numerous installations for polymer and other non-metal 3d-printing machines. Also metal 3d-printing is started in industry. However, only one investment in metal printing exists, in AM-Finland in Lahti, but several are in process to invest.

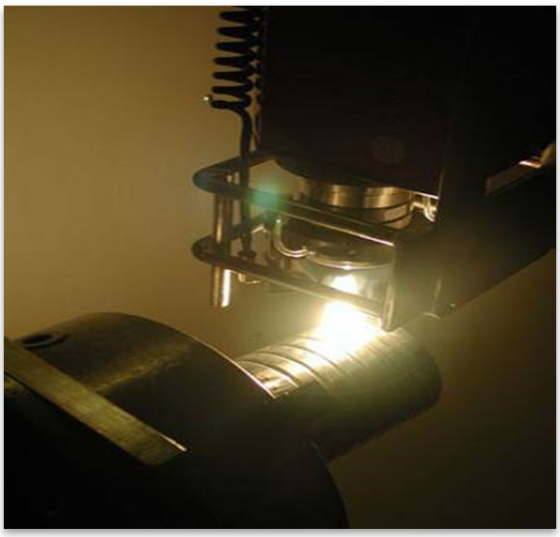

Fig. 3. Diode laser welding of a catalytic converter. (courtesy of Ecocat).

3. Research and development in laser processing in Finland

Research and education on laser materials processing is currently practiced in all technical universities, namely Lappeenranta (LUT) and Tampere (TUT) Universities of Technologies, Aalto University and University of Oulu, and in addition in VTT Technical Research Centre of Finland Ltd.

The groups are very active in publishing and servicing the industry. In addition, the universities have undergraduate and a graduate student courses in laser processing and arrange continuing education programs and seminars. LUT has the longest history, 30 years, in laser processing research. They have been active practically in most fields of laser processing, especially laser and hybrid welding. TUT has been concentrating on surface heat treatments as laser cladding. In addition, Tampere is also strong in optics and has several optics companies started from its Optical Research Centre. University of Oulu has several installations in Nivala with disc laser stations. All universities, including especially Aalto University, have been recently very active also in additive manufacturing.

VTT has been active in laser processing more than 20 years. It has mostly concentrated in laser micro processing and thick section multi-pass laser and hybrid welding, but also recently on additive manufacturing.

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.

One of the most specific R&D fields of VTT and LUT has been thick section welding. This is partly coming from the heavy section features of Finnish industry, but also research for ITER fusion reactor applications, Fig. 4. In includes large and thorough investigation of filler metal fiber, fiber-MIG, and Nd:YAG-MIG hybrid, multi-pass laser and electron beam welding of thick structural and stainless steels, up to 60 mm thickness.

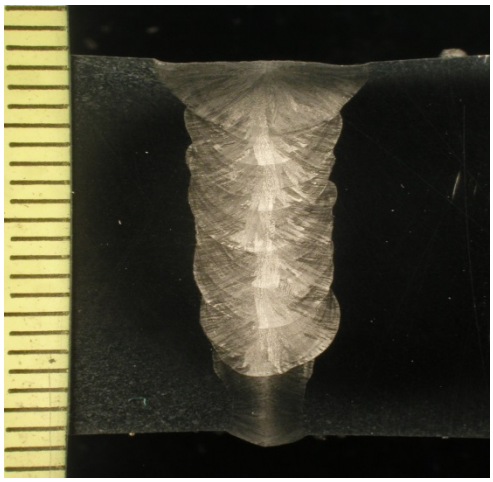

Fig. 4. Hybrid Nd:YAG laser multi-pass weld. Thickness 20 mm, AISI316 LN steel, 11 passes, welding speed in root pass 1,3 m/min, filling passes 1 m/min, laser power 3 kW, wire speed varying 9-11 m/min.

Laser Forum (established 2005) is a member society under Finnish Welding Society for interested companies to meet and update the know-how with research facilities in the country.

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, 2007 11th NOLAMP and 2015 15th NOLAMP). TUT has also arranged several conferences on surface processing, with some emphasis on laser cladding.

The international cooperation in education stepped on a new level when together with The European Welding Federation a guideline of laser processing personnel was established. It has been planned and chairmanshipped by Finnish team.

On the Masters level, the education in laser processing started in Lappeenranta University of Technology in 1987 and about 200 masters have been graduated. The first doctoral thesis in laser processing technology was done in Lappeenranta University of Technology, in 1991. Currently close to 30 doctoral theses has been defended in Finnish universities, more than half in LUT.

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