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RESEARCH ON BUCKET BORE RENEWAL TECHNOLOGIES

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Abstract: *Novel mobile (in-situ) repair technologies are extensively used for specialized equipment and machinery repairs. The reason for this is the considerable cost reductions and increase in the technological lifespan of the industrial equipment. Such parts as frames, joints or buckets can be renewed to an excellent standard using innovative in-situ technologies.*

In-situ renovation technology is itself a non-standard operation, even though the techniques used of turning and installation are relatively well studied and developed. Conversely, build-up welding processes can be studied further and potentially substituted by more advanced and economically more attractive, modern surface renovation technologies.

Key words: in-situ renovation, build-up welding technology, cladding

1. INTRODUCTION

This paper outlines initial progress of the PhD thesis (literature review) with the aim of developing a comprehensive study of bucket bore renewal technology. The overall aim of this study is to develop an economically justified, backhoe bucket borehole renewal technology, using standard and enhanced technological approaches.

A renewal technology has to meet very high standards, because the output quality must offer operating performance and durability comparable to the new product. Furthermore, surface roughness, shape and tolerances have to be identical or even superior to manufacturers' requirements. This requires an in-depth, systematic study of the pins and buckets bores, which are the most popular items for renewal. Finally, it has to be possible to provide appropriate grade with suitable in-situ renewal technology.

2. RENEWAL TECHNOLOGY

Conventional in-situ drilling and repair technologies are implemented by installing equipment directly on the damaged product using specialized centring devices. The bore central axis is used as a basis for positioning. The damaged layer is then removed mechanically by means of a turning operation. Once this is complete, the renewable surface is covered by a new layer of material using conventional MIG/MAG welding (Fig.1.). This is followed by final operation: turning to the nominal bore size.

Conventional MIG/MAG (GMAW) welding technology is one of the cheapest new layer build-up techniques and is therefore most widely used. Furthermore it is easy to adapt this build-up technology for inner surface (bore) cladding.

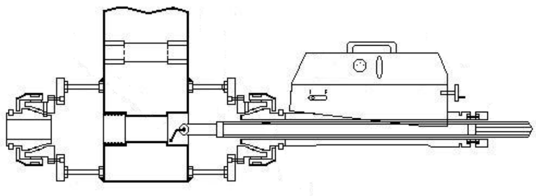

Fig. 1. MIG/MAG (GMAW) build-up welding equipment [6]

3. PROBLEM STATEMENT

It is important to note that the new material layer must equal or surpass the operational characteristics of a replacement part. It is therefore important to establish the most suitable technology from the available spectrum. Renewal operations like turning and installation are relatively well studied and developed. For these operations, it possible to adapt and use a wide range of turning and installation equipment and technologies. Therefore research efforts will mainly focus on the new material layer cladding operation. Moreover there is very little research and limited scope for relatively small bore (60-100 mm) build-up technologies [3]. The results from this research can potentially provide a greater understanding and highlight all the benefits of the analysed renewal technologies.

4. MAIN RESEARCH TOPICS

The first step is to establish the frame of reference for build-up cladding, based on the properties and features of the renewal technology. Secondly, a comprehensive literature review/research is required in order to identify as many cladding technologies as possible.
Thirdly, we have to identify and justify the most appropriate surface coating technology.
The following criteria will be used within this comparative study:

- Thickness of build-up layer;
- Potential for in-situ application of the renovation technology;
- Potential for cladding and spraying in all torch positions and directions;
- Bore size limits (min. 60-100 mm);
- Possibility to use technology for inner surfaces;
- Substrate temperature during build-up operation and base material stresses;
- Physical and mechanical properties of build-up layer;
- Costs[1].

In order to facilitate the technology evaluation process, research will commence with the five most important assessment criteria, cf. Table in Annex.

5. COATING TECHNOLOGIES

Designing a suitable surface treatment from a given combination of loads poses certain challenges. Not only is it often difficult to precisely and thoroughly understand the operating conditions of a part, but also a very wide variety of possible materials and materials technology processes have to be considered. Selecting an appropriate technology to produce a certain combination of surface characteristics is a very complex process. It involves systematic correlation of specifications with attainable surface properties. Usually, the selection process includes economic and ecological evaluations [2].
All coating technologies fall into two main groups: coating by conventional welding and surface spraying technologies. In addition, several other technologies exist for creating a new layer of metal, such as poly metal (by HOFMANN [7]) and powder metallurgy. A bush insert can also be used to create new metal layer.
These various technologies all involve different technological processes, power sources, filler materials and results.

5.1. Build-up welding

Build-up welding (Fig. 2.) is a technique where a coating is applied during a fully or partially molten phase. A metallurgical bond between the coating and substrate material is created when both the substrate and coating materials are melted [2].
In principle, every welding technique is appropriate for build-up welding. During

[1] Preliminary costs. As the technological equipment is generally an innovation and patented, it is difficult to estimate its costs.

the historical development of welding technology, each welding technique has also been used for build-up welding. Nowadays, due to process characteristics, certain welding processes or variants have become particularly popular [2].
Compared to other deposition techniques, build-up welding generally produces coatings with higher adhesion, due to the metallurgical bond created by partially or fully molten materials. The joint between the coating and substrate is never the weakest area of the compound, as long as adhesion-reducing hard phases, produced by inadequate combinations of coating and substrate material, are prevented. These coatings are therefore particularly suited to applications where the renewed parts are subject to heavy wear. Additionally, they offer high edge strength [2, 5].

Fig. 2. Build-up welding torch [3, 6]

Build-up technologies [1, 2, 5]:

- Submerged arc welding (SAW);
- Shielded metal arc welding (SMAW);
- Gas metal arc welding (GMAW);
- Flux Cored Arc Welding (FCAW);
- Plasma arc welding (PAW);
- Light amplification by stimulated emission of radiation (LASER).

These build-up welding technologies are compared in Table 1.

5.2. Thermal spraying

Thermal spraying (Fig. 3.) processes offer coatings for parts using a diverse range of coating materials to enhance wear and corrosion resistance, as well as providing a thermal barrier or producing the desired electrical or magnetic properties, etc. The basic principle and definition of the term thermal spraying is standardised in DIN EN 657. The material to be sprayed is fed to a source of heat in the form of powder, wire or rod, inside or outside the spray apparatus. Here, it is melted superficially or completely, or heated until it is sufficiently soft. A gas stream accelerates the particles towards the substrate, where they are deposited as a coating [2].

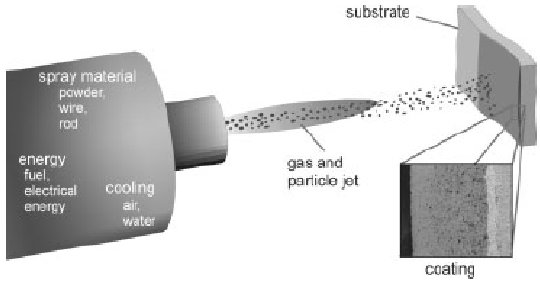

Fig. 3. Principle of thermal spraying [2]

Thermal spraying technologies [1, 2, 4]:

- Plasma spraying;
- Plasma transferred wire arc (PTWA);
- Wire flame spraying;
- High velocity oxy-fuel coating spraying (HOVOF);
- Cold spraying;
- Warm spraying;
- Arc spraying;

Table 1. shows a comparison of these spraying technologies.

6. CONCLUSIONS

This article illustrates the conclusion of the in-depth literature review, which made it possible to identify the most suitable build-up technology for industrial bucket bore renewal. Clear and understandable evaluation criteria were used and this enabled us to conclude that research should continue in the direction of GMAW, GTAW, PAW and LASER build-up technologies. A comparative table is provided in the Appendix. These four technologies fulfil the initial evaluation criteria and shall be analysed further, including the laboratory experiments and test trials.

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APPENDIX

COMPARISON OF BUCKET BORE RENEWAL TECHNOLOGIES

ASSESSMENT CRITERIA	**PERFORMANCE**							
TECHNOLOGY	SAW	SMAW	**GMAW**	FCAW	**GTAW**	**PAW**	**Build-up by LASER**	Plasma spraying
Thickness of build-up layers, mm	5 - 8 mm	2 -4 mm	**0.5 - 8 mm**	under to 8 mm	**1.6 - 5 mm**	**1 - 6 mm**	**2 - 6 mm**	up to 2 mm
Potential for on-site application of renovation technology	YES	YES	**YES**	YES	**YES**	**YES**	**INSIDE**	INSIDE
Cladding and spraying achievable in all torch positions and directions	Standard. - NO	YES	**YES – by short circuit material transfer**	YES	**YES**	**YES**	**-**	usually only Flat or Horizontal torch pos.
Bore size limits (MIN)	PATENTED	approx. 300 mm	**20 mm - 1700 mm**	20 mm - 1700 mm	**from 40 mm**	**from 75 mm**	**-**	from 40 mm
Potential to use technology for inner surfaces	Standard. - NO, there are some patents	Difficult	**YES**	YES	**YES**	**YES**	**YES**	YES
EVALUATION	Shall look forward to patented equipment	Not fit	**FIT**	FIT, but one must find benefits in comparison with GMAW, wire is expensive	FIT, however benefits and expenses shall be further scrutinised			