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MANUAL AND ROBOTIC OPERATION FOR A HOT FORGE

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Abstract

The following paper explains Automated Robotic forging planning and development. The uncertainty introduced by manually operated methods is a key issue to address in the manufacture of forges. Individual operators prefer to use an individualized method, meaning that the performance differs depending on the speed of the operator, the amount of lubricant applied, and results are inconsistent. In addition, the automation of this process, as well as contributing to output volume increases, provides improvements in quality and in performance consistency in particular. The latter function (related to the stabilization of experimental conditions) for the research investigator-means that the automated method can then be used as a process monitoring device itself, without the ambiguity that tends to confuse the process improvements that can be derived from any particular change. So the automated system can be used to diagnose the process itself. Where manufacturing operations consist of manual and automated process improvements, for example the application of lubricant can be reflected back from the automated to the manual operations.

Keywords: *Automation Robotics, Forging, Forming Press, manual operation, Hot material, Lubricant.*

I. INTRODUCTION

The University of Strathclyde's research program forging and shaping was developed in collaboration with input from world-leading companies such as Boeing, Rolls Royce, Timet, Aubert-Duvall and Barnes Aerospace. The industrial input forms a key part of the membership model-based research agenda. As part of this process, a requirement to pursue advanced automation techniques was identified as part of a strategic exercise in road mapping, resulting in the author creating a vision for automation by the author to encapsulate the main goals for automation in AFRC [1].

Industrial interaction showed that manual variability in forging, in particular, is a key determinant of product quality inconsistency and the related indeterminism may mask attempts to generate process improvements for a research organisation. Some operators take longer to move part from furnace to press; in the related processing period, even one operator varies depending on the level of tiredness and other external factors. It is therefore difficult to monitor component temperature-a main determinant of forging quality and grain size of the hit, regardless of how much effort is put on oven temperature control, because the transport time is variable [2].

Work research experiments in manually operated processes have commonly observed process variations, and are a staple of simulation exercises in manufacturing. In isolating improvements in order to be part of advanced forging and influencing technical growth, this complexity is anathema to the process experimenter. The key vision of the AFRC automation then evolved into a two-pronged strategy, to build and research advanced automation techniques in their own right, and to try to expunge or at least minimize the internet through repeatable, structured usually robotic approaches, the inherent variation in forging techniques.

Vision for Automation The author defined Automation's purpose as:

1. To generate a stable reproducible platform for forging and forming tests/experiments
2. To generate and prove automation forming techniques with 5-10 years of technical advantages that lead to existing industrial practice.

These industrial and research benefits include the following key features:

1. Increased production volume
2. Reduced variability Improved
3. Quality-dimensional accuracy
4. Reduced cost reduction in scrap
5. Improved safety process
6. Debugging capability

II. METHODOLOGY

A. Design Considerations: -

As part of implementing the Automation Capability a Forge working group was established comprising forge operators, manufacturing engineers to clarify the key integration strategies as well as the tactical implications of the various technological choices and how they would impact the project. It became clear from this interaction that there was a desire to operate the main forge– a Schuler 2000 t max screw press in both manual and automated modes to perform relatively short production run research projects on special metals as well as to have an integrated automation cell.

This meant that the automation had to be able to be stored safely in the short term from a design point of view in order to be able to execute specific manually oriented projects. For the Forge Automation team it is meant a fairly hard thinking about exactly how to balance both manual and automated operation's seemingly competing requirements. For example, a pick and place robot would be placed front and center (or slightly offset due to the configuration of the robot joints) in a permanent floor position in a traditional robotic oriented cell, making it difficult for both access and interoperability [3]. A potential configuration would be to have the handling robot on a swing arm or similar device to allow it to be deployed if necessary, but this has implications for trailing cables and repositioning, and an overhead portrait was chosen after some thought, enabling the handling robot to be securely parked when only manual operation is needed.

It was decided to pilot a particular project in the forge handling area as part of the investigative work and a Tier1 membership poll was taken to confirm that this was an acceptable approach, duly ratified by the AFRC technical board. The selected pilot project was automated lubrication & cleaning based on the application of a specialized micro-graphite suspension to the tooling, colloquially known as "dagging" A key objective here was the continuity of application and the amount of lubricant on to the tooling as well as the creation of some learning in the forge on the practicalities of dealing with applications of an industrial scale [4].

The first step was to determine what the features of the automatic solution ought to do, which included the tooling area to be covered and the robot scope, keeping in mind that in the event of inadvertent crushing, the recommendations to minimize the robots' own exposure to the 2000 tonne press process. In order to avoid the suspended graphite in the lubricant from settling into layers, it has also implemented an automatic stirring system (agitation). An occasional short stir with a stick does the job in manual operation, but all of these small measures have to be automated in an advanced system. The first step was to test different location based on specific choices of lubrication spray guns and based on this possible selection in conjunction with a possible adapter to cover the entire area, design and manufacture of the related holding fixtures/nozzle assemblies.

It was then modelled in the "Roboguide" 5 Fanuc software, which provides a comprehensive model of each of the Fanuc robots, after a first approximation of the robot assembly, and can provide motion paths and timing information for the particular type of robot chosen. It is also especially helpful as a collaboration tool because it can illustrate precisely how each team member should function in action with a specific robot and generate additional AVI video content [5].

Feedback on the simulation was then integrated into the model and a suitable mounting was then specified for the robot based on the techniques defined prior to the theme of automation for positioning a plinth on a robot pit. For this work, a student was involved and can then be exchanged for Roboguide, an approach used in other Fanuc installations, after completing the modelling work in Pro-Engineering [6].

B. **Screw Press – Automation: -**

To conduct pre-programmed load conditions and to press stroke, the screw press here needs to be remotely controlled by a master PLC. Some thoughts had to be put into what would happen if an item became trapped in the tooling, as well as ensuring that suitable communication protocols were put in place and that the master PLC was able to communicate [7]. In the case of the AFRC press, the press was ready for automation as part of the tendering process, but some form of control retrofit is always required on such major capital equipment items. Remember that particularly large presses can have a useful life usually for 50 years or more, and improvements to controls are a regular feature.

C. **Presentation devices: -**

The amount of investment involved in presentation systems is part of the problems surrounding the use of industrial automation and this aspect requires careful assessment and recognition that fine tuning will likely be necessary after the system is implemented. Because the handling and orientation systems have to be strictly aligned on the basis of a pick repeat operation (often without a vision system), then some form of vibratory bowl feed system or other arrangement is used to present components in a consistent position [8].

A strategic level review of the setup of the press lubrication allocated the dagging robot, and the M6iB/6S was available as a convenient robot supplied by Fanuc. Since it was suggested that the robot itself should not be mounted within the press jaws at any time, it was prudent to use one with a relatively long range since the AFRC screw press plates are wide and the robot should be able to lubricate as much as possible. The other robot which was initially considered to be an LR Mate used elsewhere would also have been feasible for smaller forgings but would have provided less coverage of the entire tooling area. The M6iB also provides fairly sophisticated Robot I / O capable of slaving associated devices without the need for a PLC–especially useful at the prototype / pilot level [8].

D. **Safety protocols /guarding: -**

Legislative requirements and basic consideration for personnel safety dictated early on that security guarding should be included. Because even the smaller robot (overall mass 140 kg) is capable of moving up to 600degrees per second, it has the potential to cause some damage to both the staff and the auxiliary equipment themselves [9]. Therefore guards were procured and installed internally–having first instance physical interlocks, with plans to integrate electrical integration once the final PLC was selected. The final layout depends on the placement of the horizontal upsetter and on the integration of the guard to cope with both the position of the upsetter in the single production cell [10].

E. **Automation in Practice: -**

As the growth of the automation research strand progressed, it became clear that the scientific advantages of conducting highly repeatable experiments in different forging situations were popularized. An additional incentive project emerged, linked to quenching where the benefit of repeated quenching of an object under programmable control arose. Although the automated handling system was not planned for this from the outset for a brief model in Roboguide and explained that it would be possible to quench artifacts repeatedly, thus enhancing the accuracy of the experimental procedures. This has been a phenomenon noticed elsewhere, where robots tend to be redeployed rather than replaced with other factory/R&D roles.

III. CONCLUSIONS

This paper describes the manner in which an automated robotic forging cell can be designed and implemented based on a large newspaper. The process includes clear management support from the beginning and realization of the ability to manually forge and automate forging with the same installation for some applications in a smart design. A process micro-management approach is needed which includes all the corrective actions intelligent operators take to create intelligent forges and a process for the cell layout, using CAD tolls including Roboguide, ProEngineer, has been described. While the cell remains developing at the time of writing, the basics are based on the authors' vision, which are expected to yield stable experimental finding and a basic structure for the flexible development of the technology.

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