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The Korea Convergence Society A Study on the Optimization of Manufacturing Process through Motion Analysis and Virtual Reality

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모션분석 및 가상현실을 통한 제조공정 최적화 방안연구

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Abstract For manufacturing industry to achieve efficient manufacturing process, improving a company's productivity and reducing cost is a required task of the current manufacturing companies. For design of efficient manufacturing process and improvement of productivity, efficient manufacturing process method is studied through removal of unnecessary elements analyzing motions and using test-bed linkage system based on virtual reality. When building process line after verifying optimization through virtual process arrangement simulation in advance, it is available to save additional cost for process modification or supplement to result in practical effects of improving a company's manufacturing competition. Reducing design period, improving equipment, making automation, realizing ergonomics, and improving process through this study, it will be available to achieve improvement of productivity, enhancement of quality, cost reduction as well as employees' satisfaction for safety and health.

• Key Words : virtual reality, motion study, process analysis, process design, image process.

요 약 제조업에 있어 효율적인 제조공정을 위해 기업의 생산성 향상 및 원가절감은 현 제조기업의 절실한 과제이다. 효율적인 제조공정 설계와 생산성향상을 위해 동작분석 및 가상현실기반의 테스트베드 연계시스템을 활용하여 불필요한 요소제거를 통해 효율적인 제조공정 방법을 연구한다. 가상의 사전 공정배치 시뮬레이션을 통한 최적화 검증 후 작업라인을 구축할 경우 추가적인 공정 수정 또는 보완에 소요되는 비용을 절감하고, 이는 결과적으로 기업의 제조경쟁력 향상이라는 실질적 효과를 도출할 수 있다. 본 연구를 통해 설계기간 단축, 설비개선, 자동화, 인간공학 실현, 프로세스 개선 등을 하여 생산성 향상, 품질 향상, 비용절감뿐만 아니라 안전 및 건강에 대한 직원 만족을 달성할 수 있다.

• 주제어 : 가상현실, 동작연구, 공정분석, 공정설계, 화상처리

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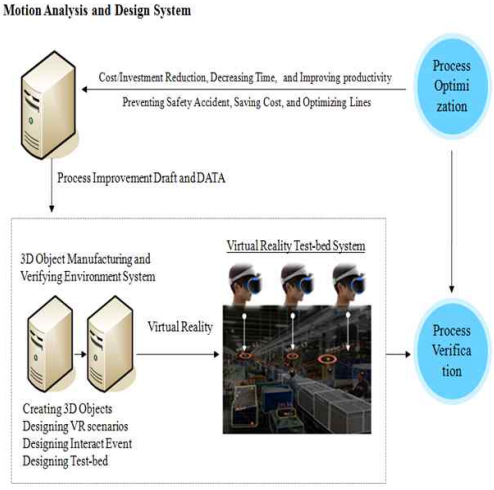
1. Introduction

The paradigm of manufacturing industries are changing globally toward flexible production methods with low cost and multi-items such as spreading convergence between manufacturing industries, IT SW service, and other industries, 3D printing, and smart factory, and the government is pursuing the project of Manufacturing Innovation 3.0 in order to responds to these changes.

This study is about building smart factory based on IT for Manufacturing Innovation 3.0's strategies to create new convergence-type manufacturing industries[1].

For building smart factory, work line system should be done first, and these management systems have been pursued by various academic and industrial organizations. However, they are not applied easily to the entire industries due to the actual problems caused by differences in use, type, or process even if they are identical products, and these work management systems have been run mainly by large-scale enterprises or middle-standing enterprises because of costly burden to install and run test-bed, and most of small and medium-sized enterprises just apply redesigned process without physical test or even cannot try it.

In this study, based on process improvement data for process analysis and design system not simple manufacturing process simulation the optimal process is designed, VR-based test-bed is offered, and work methods are improved by workers' direct management on each process and discernment of inefficient work order, batch, and line[2]. It also aims at designing and verifying the optimized process with low cost and high efficiency by decreasing T/T(Tact Time) in weak process, improving hourly productivity by line and enhancing process continuously with consideration on workers' characteristics[3][Fig. 1].



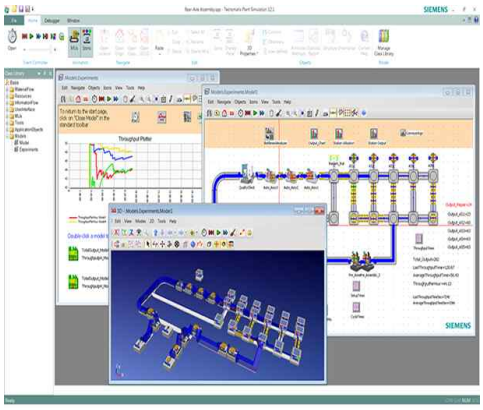
[Fig. 1] Scheme of the System

2. Current Status of the Related Technologies

With introduction of 'Industry 4.0' leading the 4thindustrialrevolutionintheworld,itistoconcentrateondevelopmentofbasictechnologiessuchasIoT.CPS,andsensorforachieving'smartfactory'inordertointegrateandmanageproductionprocess,procurement/logisticandservice[4,5].

According to the research expert in industrial sector, Frost and Sullivan's Analysis of the Global Digital Manufacturing Market published in 2013, which search for the optimized production scenarios by finding and improving various problems in virtual factory through production simulation in advance., continues to grow and it is expected that the size of digital manufacturing market will be about USD 928 million in 2016[6].

There is no case of development of a technology to link motion analysis and virtual reality system in this study, yet, and automobile companies, which should change design and modify production equipment whenever new types of automobiles are produced, lead to build digital manufacturing process. For overseas cases, automobile manufacturers such as BMW, Mazda, and Chrysler apply Technomatix solution and reduce product period, work time, development cost, and investment cost[7][Fig. 2].



[Fig. 2] Design and Simulation of Process for Siemens Technomatix

For the domestic cases, Seoul National University and Samsung Heavy Industries built a system to simulate every process for innovating shipbuilding yard's process in virtual space. In addition, ETRI developed a virtual production process verification platform through R&D to mingle the actual space and virtual space of VR technologies and to apply mixed reality for making users experience it[8].

For the current status of the domestic and overseas technologies in production training simulation, it is available to prevent safety accident during technical training and to conduct sufficient training without wasting expensive resources, and multiple-to-one training can be applied, resulting in quick acquisition of sophisticated skills. Therefore, various sectors such as automobile, ship, and nuclear plant conduct R&D on it and introduce it.

3. Limitations in conventional activities of process innovation

Process innovation (activity) conducted currently in manufacturing sector is done in the form of redesigning process removed its risk and waste elements based on motion analysis system and verifying it through realization of test-bed in physical space. These process innovation activities are usually conducted intensively for some education time according to standard work guideline to apply it on the site[9].

Field training requires lots of time from field to effect due to temporal and spatial limitations. That is, it takes huge cost and lots of time to find various variables which cannot be expected in design phase such as characteristics of suitable workers in real-time, to feedback them in process analysis and design system immediately, and to design and verify optimized production manufacturing process, and it is available for large-scale enterprises or some middle-standing enterprises. Therefore, 99% of Korean manufacturing sector, small and medium-sized enterprises have the actual limitations to introduce it[10].

4. Demand on a low-cost and high-efficiency system for validating a process design

Recently, VR technologies have been considered as those to replace physical test-bed in process innovation activities, and education and training simulation systems related to them are being developed.

The systems until now, have been partially applied to research or large-scale equipment industrial factors focusing on automobile, shipbuilding, universities, or large-scale enterprises, and these systems are for education and training to exchange designers' thoughts and to deliver skilled workers' know-how in specific process, different from systems to figure out characteristics of workers by process and to design optimized production manufacturing process.

About 99% of Korean manufacturing sector, small and medium-sized enterprises have usually process to assembly parts according to work order focusing on workers with vulnerability in funding. Therefore, for process innovation in small and medium-sized enterprises, it is necessary to study optimized process design and verification system with low cost and high efficiency available for applying on the site of most of manufacturing enterprises not simulation system for designing products or educating and training[11].

5. Economic and social aspects

Development of IoT. M2M, and big data, sensor, and ICT leads to the 4th industrial revolution through smart factory and competition among manufacturing enterprise will be deeper infuture. Also, Open Source Hard Ware(OSHW) and 3D printing technologies ares haking the ecosystem of the existing manufacturing industries through digital manufacturing.

The core management technology of smart factory, Cyber Physical System(CPS) pursues convergence of cyber-world consisting of systematic objects such as sensor, actuator, embedded-system and physical objects co-existing with human in physical world, with core concepts of 3 elements of communication, operation, and control. Objects in physical world mean all the things and natural environment which can interact with human, and USA leading in CPS sector, suggested 7 core utilized sectors of CPS, and the first one is 'smart production process system[12,13]'.

This study will maximize production efficiency of enterprises and contribute greatly to leading to convergence of ICT based on smart factory by reviewing efficiency of resources through pre-simulation and End-to-End engineering as technologies required for surviving in these competitions, and providing optimized test-bed of production process using VR technologies.

6. Technological ripple effects

Through reducing design period, improvement of equipment, automation, realization of ergonomics, and enhancement of process, it is available to achieve a company's competition indices, production improvement, market release interval reduction, enhancement of quality, and cost reduction as well as customer's satisfaction in design and service, and employees' satisfaction in safety and health. In addition, when verifying optimization through virtual pre-process arrangement simulation and building work line, it can remove cost for additional process modification or supplement, and it will result in practical effects of production cost reduction and improvement of company's competing power[14,15].

7. Diversification of applications

As different industries such as defense and medicines provide test-bed based on simulation and virtual reality, it is available to develop diversified derivative products, and it is possible to apply 3D objects from various sectors to contents service available for purchasing and using according to needs after manufacturing them. It can be extended to education and training system using virtual reality.

8. Conclusion

In order to survive in the global competing era, it is necessary to conduct continuously the most effective time management system and the standardization of improved work management system for achieving it.

For designing effective time management system and manufacturing process and improving productivity, this study aimed at removing waste of weak process and improving hourly productivity by line through improving work methods by removing waste of unnecessary elements using motion analysis system and virtual reality, seeking the most reasonable manufacturing process, discerning inefficient work order, batch, and lines.

This study is about development of process design verification system with optimized low cost and high efficiency for most of Korean small and medium-sized enterprises, and it is manufacturing process simulation available for simulating the entire manufacturing line in virtual reality and suggesting process improvement effect with quantitative values. In addition, it aims at providing remarkable improvement in productivity and competing power of companies by removing

uncertainty against dynamic analysis system and suggesting optimal alternative of equipment investment cost for test-bed. Accordingly, the system developed by this study is required for leading investment from most small and medium-sized companies which are negative to invest process improvement due to uncertainty and economic reasons and for strengthening the domestic and international competing power in manufacturing industries.

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