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Improving Work Efficiency by Implementing *Digital Standard Operating Procedure (DSOP)* in Manufacturing Process

(Case Study: Conventional Lathe Machine)

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Abstract

The development of the use of digital-based technology has become a challenge as well as an opportunity in Industry 4.0 era, especially in the manufacturing industry. The machining process is one of the important and dominant part in the implementation of the manufacturing industry, so it is necessary to find a way to get the expected results with time efficiency in the process because it will be a factor that determines the total operating costs incurred. To optimize all used resources and minimize engine idle time, the Digital Standard Operating Procedure (DSOP) method is a solution. DSOP is one step in digital transformation in order to optimize guidelines for the implementation of the machining process which also replaces working papers as operator guidance on the production floor. The method is used to compare the time required by the operator in carrying out the machining process using the DSOP with the old method. From the day of observation, it was found that there was a time saving of up to 50% by the operator, compared to conventional machining process methods. Digital SOP also provides a more communicative guide accompanied by complete pictures of the products made, as well as videos on how to set-up tools and workpieces on machines. With the use of digital-based SOPs, the time required for operators is shortened and SOP is understood more accurately from planning, monitoring until implementing, which are presented digitally

Keywords:
Digital SOP, Industry 4.0, Digital transformation, Machining Process, Manufacturing

1 Introduction

Information Technology (IT) is the pillar of many companies in the world as a supporting factor to achieve their goals [1]. Information technology has now become a very important need for all corporate organizations since *Covid-19* pandemic, and IT advances also have a major impact on industry and society [2], and it is believed to be able to improve the effectiveness and efficiency of the company's business processes. The pandemic impacts the dynamics that change the world [3]. However, there are still many industry players, especially manufacturers, who still carry out monitoring steps and provide guidance in conventional ways such as the use of working papers and handwriting. IT is developing very fast, especially in the 20th century there is a lot of industry 4.0 that has sprung up, provides many changes. It is also able to provide benefits to industry players [4] . On the manufacturing process point of view, there are also many benefits from IT development, through automation of several processes and even almost all existing processes. *Digital transformation is* present and affects the process of forming operational value, enabling new ways of doing business and leading to fundamental changes in the organization [5]. The presence of advance technology brings a new color in the manufacturing world which is also able to change culture in a process and is able to optimize all existing resources. Among the processes often used in a manufacturing process, the machining process is the one that has the most crowded activity in the manufacture of a product/goods. So, some create technical services that allow machines to communicate and cooperate with other machines or manufacturing elements, as well as with the remaining business processes. The machining process is one of the advanced processes in the formation of the workpiece, or it may also be the final process after metal is formed into raw materials, which begins by designing the object using *Computer Aided Design (CAD)-based software* [6]. The machining process commonly involves several machines, and uses several different types of blades in its implementation [7]. Thus, information about the machining process must be presented as completely as possible so that the process can be carried out optimally and efficiently, especially when there is a shifting from one machine to another. The machining process includes the planning process, creating working cards, preparing tools and other tools, implementing process to monitoring process, so that products that match the desired geometry and dimensions are obtained [8]. If any of the required information is not available properly, it will result poor communication that can trigger delays which may affect the next process [9] .

SOPs or Standard Operating Procedures are documents that describe operational activities within an organization in stages so that each personnel can understand clearly and easily follow [10]. Standard Operating Procedures (SOP) or in Indonesian called *Standar Prosedur Operasi* (SPO) is very useful for service providers and recipients [11]. In the implementation of processes that occur in a workshop, SOPs also have a very important role which is used as a guide for all parties involved in the workflow. Through SOPs, each section can focus on its role so that it can maximize the implementation so that other sections can also carry out their respective functions, because all the functions in the workshop are one unit that are interconnected. However, all sections are still focused on their respective work where all data is still written with handwritten explanations and this of course can lead to data inconsistency and insufficient data in supporting the entire process.

Recent advance technology has greatly influenced the world, business, education, especially the manufacturing world in the automotive sector [12]. Changes due to digitalization are proceeding at an ever-increasing pace, developments are changing our entire world, and completely changing the production and labor markets [13]. Thus, with digital technology, a digital-based SOP is designed, which is known as DSOP for the implementation of the process in the workshop. The Industrial Revolution 4.0 empowers the role of manufacturing digitization in the supply network which involves the integration of information from various sources and locations to physically drive manufacturing and distribution. The concept of IR 4.0 is based on well-known technologies that have driven the cloud-based economy: Big data, machine learning, and data science techniques [14]. The purpose of this DSOP is as a substitute for the communication media commonly used by each party involved in a process in the workshop, so that by using this method it can minimize time used, improve operator understanding, and at the same time replace the

usual working paper (hardcopy). In today's technological era, the influence of technological developments has affected all aspects of business activities, such as the exchange of information, the marketing patterns that are carried out, the trading system that is formed, as well as the things production [15]. The use of DSOP has not been found in many implementations, especially workshops, but several articles have proven efficiency in quality testing [16], facilitating communication between the site and the control room through sensors [17], and in the field of service providers in determining the order of work [18].

2 Research methods

The method used is to describe the current SOP in the workshop and then create a mapping of the expected results/conditions which becomes the basic information for creating a digital SOP concept (Fig. 1).

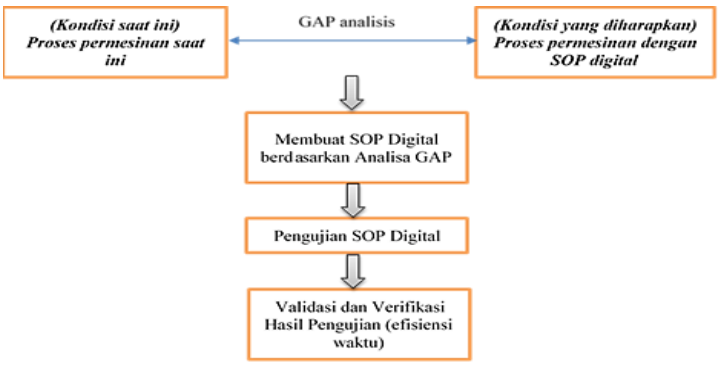

Fig. 1. Working Methodology

To determine the flow of the SOP is still based on the steps taken while still using conventional methods. The difference is that when using conventional methods, the entire process is carried out using working paper media as a media of communication and the parties involved *(engineering process, supervisors, tool rooms, operators)* are still carrying out their respective functions without using digitization. The steps in the preparation of digital SOPs are as follows:

1. Determine the product/object.

This stage is the beginning of the work where the work object that will undergo the machining process is revealed from the type of material, size, to the desired final result. The product or the workpiece must be identified at the outset because each type of material has different properties, so it should not have the same treatment so that the planned final result is achieved. By knowing the general characteristics of the workpiece as the object of work, the next process is the engineering will prepare general drawings to details.

2. Prepare technical drawing of the product to be made.

The process of preparing technical drawing must be carried out with a comprehensive understanding. In general, technical drawing is a picture that is firm, consisting of lines, symbols and words in certain standards that have been mutually agreed upon, so that they become a means of visual communication between planners (architects) to convey ideas or proposed designs to executors in the field so that it is conveyed properly and clearly in accordance with the objectives. Technical drawings use certain standard so that technical drawings are understood well to be worked on. So that the engineers or architect must understand drawing standardization, projections, intersections, drawing symbols, production methods and production tools and its costs. After the drawing has been finalized, it is prepared in the form of a file (digital) because it will be included in the platform.

3. Determine the machine to be used.

After the technical drawing is prepared, the next step is to determine which machine will be used to work on the machining process. Of course, there are many types of machines that can perform the same machining processes with each other. However, the determination of the machine here aims to facilitate the selection of tools, parameter settings and others because they will be included in the platform considering that each machine will have its own uniqueness. Even if a conventional lathe machine with a CNC machine can carry out the same process, it will definitely be different in terms of workpiece installation, chisel installation, parameter settings and other setups. That is the reason it is necessary to determine the machine that will be used at the beginning.

4. Put all elements into the platform, which consists of:
   a. Technical drawings of the workpieces: Technical drawings are added so that the operator can see both in general and specific on the object to be made. The images that are included are also varied in view so that the operator is easier to understand and does not take long to interpret.
   b. Tools used: with the final design of the object that has been planned and the technical drawings that have been prepared, process engineering can already include a list of any tools used from the initial setting process to the machining process. Thus, the operator only goes to the toolroom once to pick up the equipment and tools that will be used, which will save more time.
   c. Cutter setup process: the cutter setup process steps, documented as videos and images, are added into the platform so that the operators are easier to place and adjust the cutter used. The platform also includes setup sequences especially when required for more complex installations.
   d. Determination of the location of the workpiece (documented as photos and videos): apart from the cutter setup step, the workpiece setup is one of the most important things for the operator to understand. Starting from determining the starting point (datum) for the machining process until the last process. It also includes how to use tools to lock the workpiece, the position of the rotation, and how to bring the workpiece closer to the cutter, documented in videos and pictures.
   e. Allowable tolerance: tolerance is one of the most important aspects when machining an object. In the flatform we also include tolerance elements at each stage so that operators are reminded to pay more attention to tolerance made up.
   f. Sequence of workmanship: this sequence aims to give the operator an idea which part will take precedence when the machining process is carried out. With the work order on the platform, the operator will no longer have to worry about the setup that will be done at the beginning, because process engineering has provided steps that must be followed through the application. They simply run it in the order that has been prepared.
5. Time recording

Time recording aims to get the optimal time in carrying out each stage in the application. Time records are made as a reference to operators that the reference time is listed as the time they should achieve, as a minimum standard in each stage. This time recording is also useful data to determine how much average time is needed by the operator for each step taken when working on the machining process.

The designed platform will generate comparisons of the time needed in carrying out the machining process. The factors that

become important points which need to be considered are; file distribution time (image, z-code, work parameters), tool setup time, tool and workpiece setup time, result recording process. These factors are compared over time, between using conventional methods and with DSOP.

3 Results and Discussion

The process description in Fig. 2 shows the object to be made and includes some important information in general that is passed for the machining process.

Fig. 2. Process overview

After getting all the parameters and equipment needed for the machining process, they are inputted into the platform to be used later by the parties involved in the machining process. All stages are now in digital form and can be accessed through the application without the need for paper as a medium for printing pictures and other instructions because they have been prepared in the form of videos and photos available in the application.

3.1 Difficulty level

The level of difficulty here shows how difficult it is to create a product. This can be seen from the complexity of the product surface and also the complexity during the machining process. There are 4 levels of difficulty in this application; easy, medium, moderate, and hard, but making this level depends on the application developer and according to the needs. By looking at the level of difficulty, the operator can understand and look deeper more carefully at a glance into the steps that have been prepared by the engineering process on the platform. In making the product (as in the example) in Fig. 3, the difficulty level is moderate, so close to hard. So that by just looking at the level of operators and people involved in the machining process, they are able to assess what complexities will be faced in making the product.

3.2 Steps

The steps in making the product are presented in the process steps, starting from how to select the tools used, set the parameters and chisels, to the machining process to be carried out along and also the tolerances allowed. This section is the most important aspect in designing the digitization of SOPs because this stage is the core of the process of making a product. The steps must be very detailed so that even if the operator is a new employee, with the prepared steps, the new employee can run without facing any problems. Very detailed images and videos are made to make it easier to implement.

3.3 Time required

With an integrated system starting from the tool preparation process to initial settings, each step can be estimated. Each step will be given a time of how long (in seconds) the step occurs, and so on as in the example in Fig. 3, as many as 22 steps. So, the time required for the process of working on the product has been estimated at the beginning, so that this time becomes a benchmark for operators to be used as a reference in the implementation of the machining process. If this time is not met, the operator will give the reason for the delay and make a note for the supervisor for further work which will also be reported to the process engineering whether the steps made need to be revised.

3.4 Section

This menu describes how many parts will be done in one particular machining job. From the explanation in fig. 3, it shows that there is only one section, namely the Turning of Back Cover machining process - Electric Motor Casing.

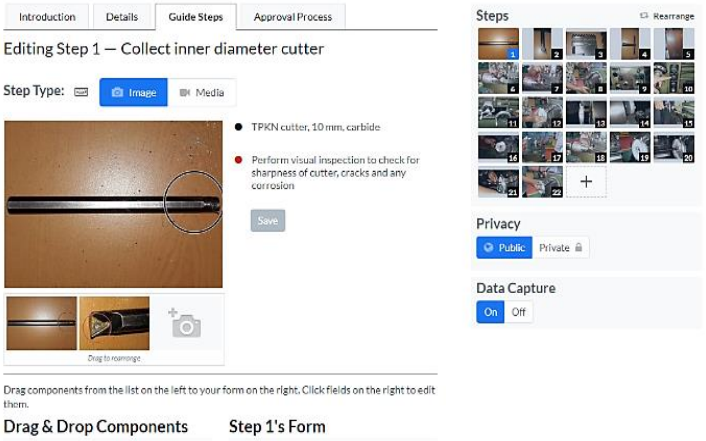

Fig. 3. Instructions for Selection of Cutter Type and Diameter

So it can be seen in the digital SOP that was made there is only one part of the work. If we want to make a complex job consisting of 10 different parts, then there will be 10 sections where each section will have different stages according to their respective levels of difficulty. This section is adjusted to the complexity of the process to be carried out. In general, if the process is not too difficult, then one workpiece will only have one part, but if the complexity is more then several parts can be made so that the operator will not be confused in reading the long stages.

3.5 Flags

The intended marker is the number of markers used in the stages that have been compiled as shows fig. 4.

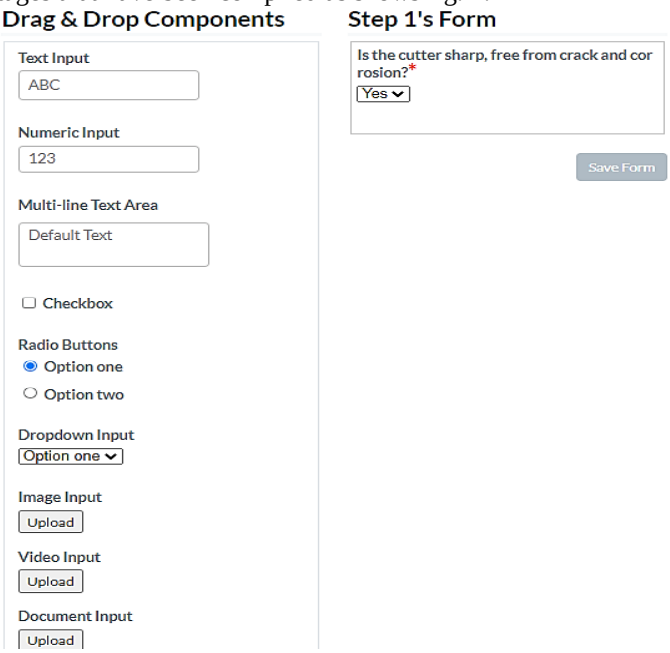

Fig. 4. Put The Parameters Into Stages

the number of signs used is only 1 (out of several signs prepared by the application), namely a triangle sign with an exclamation point in it. The use of signs is still adjusted to the needs during the machining process, so that the operator sees everywhere there are critical points that must be considered and get greater attention.

3.6 Enter component and Review results

The digital SOP has been successfully used as a procedure guide for the process of selecting tools and devices, determining parameters, tolerances to machining processes. Determination of the type and size of the tool shows Fig. 5

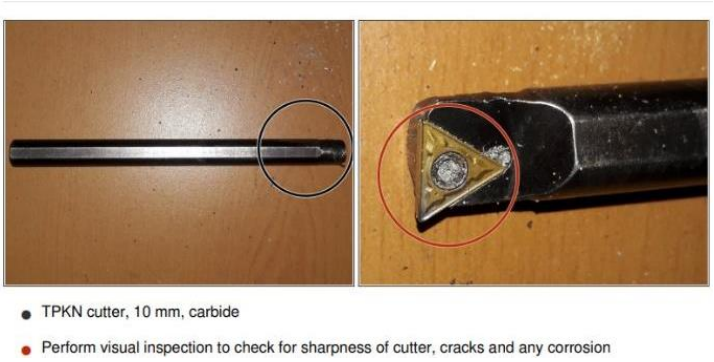

Fig. 5. Tool Condition Check

There are many types of chisels in the tool room, so that with the digital guide, the operator does not need much time to choose the tool to be used, and which shape is needed, because in addition to including the size, the Digital SOPs are also attached with pictures of the tools/components used.

In addition to the selection of the type of tool, an aspect that is no less important is the selection of tools in the form of a tooling key that will be used during the process from putting the tool into the machine until it is replaced with a new type (mount-unmounted) as in Fig. 6. The keys needed during the machining process will be taken at once when they first enter the tool room, in order to save time in terms of mobilizing supporting equipment. With the application and the tools that have been determined, it makes it easier for the operator to take all the equipment used during the machining process and not go back and forth to the tool room.

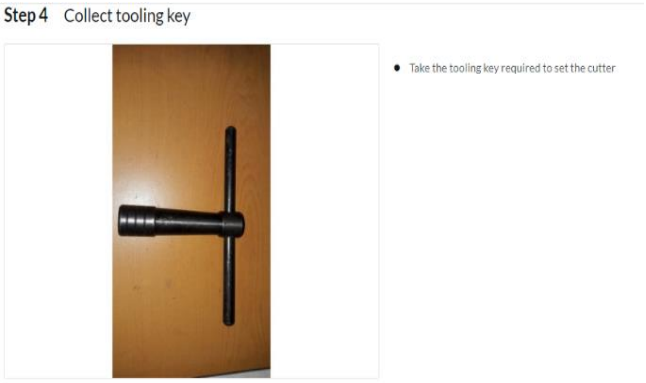

Fig. 6. Type of Key Used

In starting the work process, the main thing to do is to determine the starting point (datum) as shown in Fig. 7. This stage is very important because it will determine the accuracy of the machining process, and become the reference point for every tool movement during the machining process. Through a digitally prepared guide, the operator will easily understand the starting point of setting and which part of the work piece to be worked on first.

The engineering process has prepared sequences in the form of images and videos, which makes the execution process easier when it is applied to the machine. In addition, the position of the work piece with the reference area is also one of the important points that must be considered as shown in Fig. 8. The alignment position in this case is considered absolute to ensure the quality of the object to be made, so it must get special attention from the operator. With the machining process guide prepared in digital form, it will reduce preparation time and also save unnecessary time during the process.

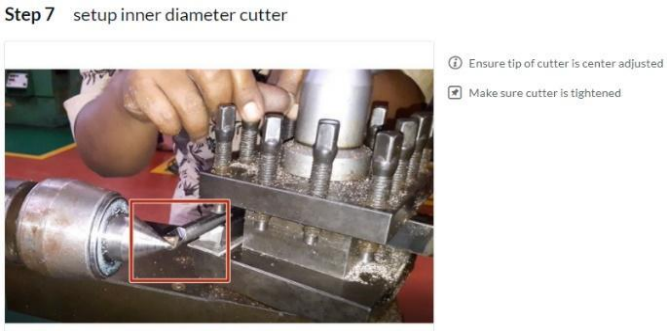

Fig. 7. Determination of Starting Point (Datum)

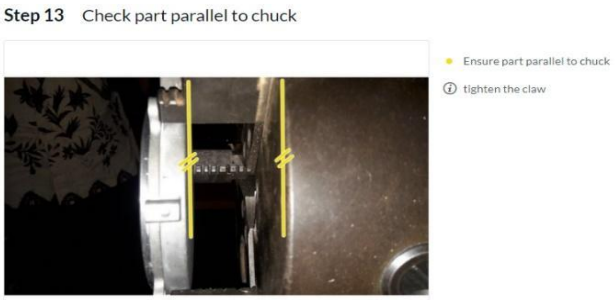

Fig. 8. Instructions for laying the position of the workpiece and the work area.

In addition, the manual in digital form will reduce the dependence on the use of paper as a medium of communication between the engineering process and all related sections, as shows table 1.

Table 1. Comparison of old SOPs with Digital

No	Stages in machining	old SOP	digital SOPs
1	Document submission	Paper	Digital logging
2	Technical drawing	Print out	Images in digital
3	Guide of choosing the type of cutter and its diameter	N/A	Image
4	Set-up cutter	N/A	Images/videos
5	Workpiece set-up	N/A	Images/Videos
	chisel size		Images/Videos
6	Tools used	Depends on operator	Image
7	Determination of starting point (datum)	Depends on operator	Determined via digital
8	Machine used	Depends on operator	Specified image/video
9		N/A	Optional

The results of the average calculation of the time spent by the operator in carrying out a machining process (Table 2).

Table 2. The results of the average calculation of the time spent by the operator in carrying out a machining process

No	Stages	Old SOP (minutes)	Digital SOP (minutes)
1	Document submission	10	1
2	Technical drawing setup	10	1
3	Selection of cutter type and diameter	5	2
4	Cutter Set-up Time	5	3
	Workpiece Set-up Time		
5	Tool size determination time	5	3

6	Selection of tools used	10	2
7	Determination of starting point (datum) Determination of the machine used	10	5
8		2	2
9		10	2
	Total	(67 Minutes)	(21 Minutes)

In table 2 the average time, it shows that there is a very significant difference in the time spent by each operator in preparing documents, understanding, installing tools and workpieces, until the machining process is ready to be implemented. The time difference required can be reduced by up to 1/3 of the usual time using the DSOP. The existence of a connected facility between the party who prepares the Engineering process (EP) and the party who will use it in the workshop (operator) makes it easier to understand and provides clear instructions about size, tolerance, type and other parameters through images and videos displayed on the DSOP. It is also easier for the operator to communicate if there are technical matters that must be confirmed to the EP

4 Conclusion

Digitization of SOP (DSOP) is beneficial for the efficiency of machining process preparation time compared to the use of conventional methods. The average time saved is about 2/3 when using the DSOP method compared to conventional. The use of Digital SOPs also minimizes the occurrence of errors in the machining process preparation process because it is equipped with additional features in the form of images and videos.

References

[1] A. Rachmi, T. D. Susanto, and A. Herdiyanti, "Pembuatan Standard Operating Procedure (SOP) Service Desk Berdasarkan Kerangka Kerja ITIL V3 dengan Menggunakan Metode Analisis Gap Layanan (Studi Kasus : PT XZY Tangerang)," *J. Tek. Pomits*, vol. 3, no. 2, pp. 175–180, 2014.

[2] V. D. Soni, "Information Technologies: Shaping the World under the Pandemic COVID-19," *J. Eng. Sci.*, vol. 11, no. 6, pp. 771–776, 2020.

[3] N. Bakaianova, Y. Polianskyi, and O. Svyda, "Information technology in the litigation due to the pandemic COVID-19," *Cuest. Políticas*, vol. 38, no. Especial II, pp. 485–499, 2020.

[4] P. Fernandez, "Pandemic response technologies: information ecosystems," *Libr. Hi Tech News*, vol. 37, no. 9, pp. 7–10, 2020.

[5] I. A. V. Damanik and N. I. Sinisuka, "The effect of voltage variation (160-240volt) on lighting quality and color properties of LED lamps in Indonesia," in *3rd IEEE Conference on Power Engineering and Renewable Energy, ICPERE 2016*, 2017, pp. 179–183.

[6] V. Gilart-iglesias, F. Maciá-pérez, D. Marcos-jorquera, and F. J. Mora-gimeno, "processes," 2007.

[7] J. Teknik and I. Uns, "Pengaruh Waktu Proses Permesinan dari Penetapan Urutan Pahat Proses terhadap Sumbu z," vol. 2, no. 1, pp. 15–23, 2003.

[8] K. Kumar, H. Kalita, D. Zindani, and J. P. Davim, "Machining Process," pp. 85–100, 2019.

[9] I. Lesmono and Yunus, "Pengaruh Jenis Pahat, Kecepatan Spindel, dan Kedalaman Pemakanan Terhadap Tingkat Kekasaran dan Kekerasan Permukaan Baja st. 42 pada Proses Bubut Konvensional," *Jtm*, vol. 1, no. 3, pp. 48–55, 2013.

[10] N. Wangskarn, J. Siritantitam, N. Meesri, and P. Chiravirakul, "Flowty-Flow: A Web application for preparation and distribution of Standard operating procedures," *Proc. 2016 5th ICT Int. Student Proj. Conf. ICT-ISPC 2016*, pp. 21–24, 2016.

[11] A. Utama, "Standar Penulisan," pp. 1–19.

[12] C. CENTER, "Meningkatkan Produktivitas Pembuatan Chucking," *Researchgate.Net*, 2015.

[13] B. Fregan, I. Kocsis, and Z. Rajnai, "Risks of Industry 4.0 and Digitization," *Műszaki Tudományos Közlemények*, vol. 9, no. 1, pp. 87–90, 2018.

[14] L. BANICA and C. STEFAN, "Stepping into the Industry 4.0: The Digital Twin Approach," *Ann. Dunarea Jos Univ. Galati. Fascicle I. Econ. Appl. Informatics*, vol. 25, no. 3, pp. 107–113, 2019.

[15] Sani A, "Standar Operational Prosedure (SOP) Sebagai Kunci Pembenahan Masalah dalam Mekanisme Pelaksanaan Program Pendampingan Ekspor," *J. Kewidyaiswaraan*, vol. 5, no. 1, pp. 59–70, 2020.

[16] T. Schmidt, W. Lemmerz, C. Stumpf, W. Corporation, and U. S. Ma, "Elect Ronic Sop and Workflow Syst Em," 2005.

[17] J. E. Kim and C. H. Hong, "A study on methodology of digital-SOP system for effective disaster response," *5th IEEE Int. Smart Cities Conf. ISC2 2019*, pp. 741–746, 2019.

[18] M. Lubis, H. H. R. Ananza, and F. D. Suryoputro, "Analysis and Design of Policy and Standard Operating Procedure (SOP) for Information Technology in the Communication and Information Services Department," *6th Int. Conf. Interact. Digit. Media, ICIDM 2020*, no. Icidm, 2020.