A Quarterly Bulletin of Metal Forming Research Laboratory

Bulletin MFRL

School of Mechanical Engineering, Universiti Sains Malaysia

April 2023 Volume 7 Quarter 2 eISSN 2550-2069

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STG - Matching
Title: Tribological Performance of Additive Manufactured Aluminum Alloys, 2021-2023

FRGS Grant
Title: Investigation on the effect of hot forging on the deformation behavior and microstructural response of Wire Arc Additive Manufacturing (WAAM) of high strength low alloy (HSLA) steel components, 2022-2025

Preface

Continuing to provide an enjoyable and safe learning environment and updated research facilities is the main aim once the lab is initiated. Since 2006, when the mechanical press machine was first bought, to 2011 when the enclosed building was completed, 2017, when the 1st MSc student under my supervision finished his study, and 2020 when the 1st PhD student obtained his doctorate, a lot of events have happened, and a few number of students have benefited from the facilities provided in the lab.

2023 will mark a new history for the lab as it begins to be recognized internationally as four students from different countries registered for their PhD studies. Hopefully, their existence may prosper the lab and raise the lab's name from their future findings.

However, local talent needs to be continually supported and trained for the benefit of the nation. May Allah help us.

Webinar Series 3

In continuation of the previous two series of webinars organised in 2022, the third webinar will be arranged on May 17, 2023. Two presenters, Kamarul Al-Hafiz and Amer Isyraqi, will share part of their research findings. Both are PhD students who joined the group in 2020. The research topic is the performance of FSW, which will be studied from two different perspectives. Kamarul will investigate the formability aspect of the FSWed blank during the SPIF process, while Amer will focus on the joint configuration in FSW.

New Members - 2023

The lab is honoured to welcome three new international PhD students. Muntaka Musa from Nigeria, Jiang Aimin from China, and Atheer from Iraq. All of them just registered in March 2023 and have just started their research. Muntaka will focus on the application of CAD/CAM in metal additive manufacturing, while Aimin intends to study AI applications in metal additive manufacturing, and finally, Atheer will work on the machining of composites in aerospace.


Jiang Aimin (China)


Muntaka Musa (Nigeria)


Atheer Najm Abed(Iraq)

applications.

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Features Hierarchy Based Metal Forming Process Identification Tools

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INTRODUCTION

The metal forming process is among the most widely used manufacturing processes by many companies. Historically, forging is claimed as the pioneer operation, which was invented in the 13th Century. At that time, hammer is the main tool and manually form the metal. After fully mechanical machinery was invented, where the hammering tool that is mounted on the level arm, raised by the waterpower, and then let it fall under the force of gravity to generate the huge forging force and deformed the material into the intended shapes. However, only simple shapes can be formed at that time. It was recorded that Leonardo da Vinci invented a rolling mill machine in 1480 for soft material likes lead (Pb) and glass and in 1495, two rollers for coin making was invented. The technology grows, at the end of late 18th century, demands for high volume metal parts motivate further evolution of the machinery and the operation to produce more complex shapes.

Metal forming process can be described as a process where a material in the form of sheet or bulk was plastically deformed into value-added part by a forced that was exceeds the material yield strength using specially designed pair of tools. It can be classified into sheet and bulk metal forming processes. There are four main types of metal forming processes, which are bending, drawing, forging, and rolling. The first two are sheet metal forming, while the remaining two are the bulk metal forming process.

The metal forming process variants are too many and it is confusing for those who are firstly met the part likes undergraduate students as the processes are similar and difficult to be differentiate. This is based the on survey conducted. More than 70% of them are either difficult or may have difficulties in recognizing the name of the process based on the given metal part as shown in Figure 1. This is because most of them found that the processes are the same and too many names to be memorized. Table 1 provides a few examples of similar metal processes and similarities between them.

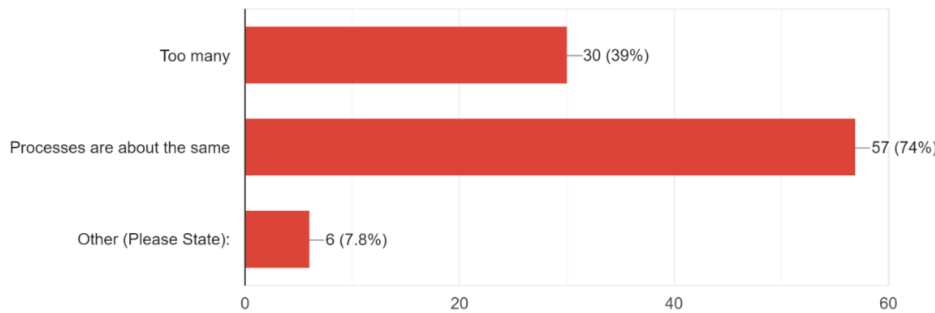
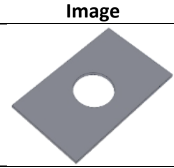
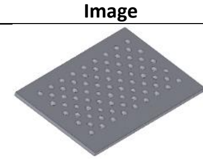
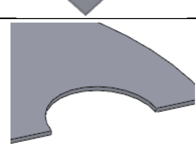
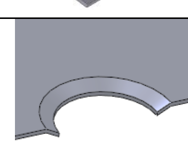
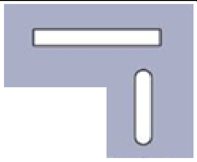
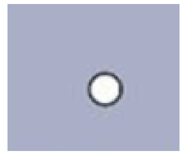


Figure 1: Result of the student survey the reason for their difficulty.

From literature, visualization is among the most effective methods to recognize component or part names. Shabiralyani et al., (2015) claimed visual aids as the best tool or devices which are used in classrooms to encourage students learning process more effectively and make it easier and interesting in dissemination of knowledge. Similar finding, in the survey conducted. Almost 90% of the students think that visualization is the best tool to speed up their understanding in recognising the names. While other method, but still presented visually. i.e., schematic diagram may also help them. Jagirdar et al, (2001) developed a method to identify part features. In other work, Gupta et al., (2021) used STEP to identify features on sheet metal parts. Each of the features are defined as the number, type, and connectivity of geometric entities in the part model. Liu et al., (2004) automatically extracted part features from solid model. The method involved validation of the model geometry, feature matching, and feature relationship. They target feature rebuilding and stamping process planning. Similarly, Kulkarni et al., (2016) developed a method to improve part features from the CAD model. In other work, Behera et al., (2012) suggested an algorithm in detecting features specifically applied for single point incremental forming. While Hussein et al., (2013) developed a system to extract features from a free form shape. Eleven features including V-notch, U-arc notch, U-straight notch, arc notch, round hole, square hole, rectangular hole, single D-shape and finally slots can be extracted. In metal forming process identification, Sharma (2016) proposed the use of virtual simulation lab, which is developed in web to assist student in understanding metal forming setups, various process parameters, materials, and equipment involved in the processes and many more. Hamouche and Loukaides (2018) utilized machine learning in selecting suitable manufacturing processes to replace unstructured and heavily reliant on human expertise. Same work was done by Shue et al., (2020) utilizing deep learning. They concluded that a better approach and performance was gained from the system. Ghaffarishahri and Rivest (2019) developed an automated features recognition system specifically for structural sheet metal parts on airplanes. They target design reuse and model comparison. In part modeling, features are the main element that can be used to differentiate part. Part differentiation must own unique and distinctive characteristics or features to the others. In the next section, part features will be further explored and understood.

Table 1 lists few examples of similarities of metal forming processes.

Process 1	Image	Process 1	Image	Similarity
Punching		Perforating		Both processes produce holes. The difference is punching produce single hole, perforating produces many holes
Punching		Dimpling		Both processes produce holes. The difference is punching produce straight cut hole, dimpling produces hole with flange.

Punching		Piercing		Both processes produce holes. The difference is punching produce various hole or cutout shapes, piercing produces circular holes

PART FEATURES

Sheet metal parts can be described as a simple element with a topological shape that can be displayed in 3D view. Typical subsidiary features are bends, pierced holes, extruded holes, embosses, lancing forms, hems, beads, slots, bosses, ribs, and set outs. (Rui et al., 2010). Figure 2 illustrates a few features on a sheet metal part.

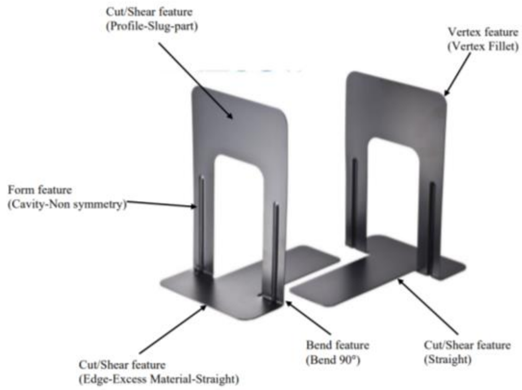


Figure 2: Sheet metal part features

The part features are then expanded by looking into the similarities, begins with highest hierarchy of similarities, either it is a discrete or continuous part. The features are further specialized as the hierarchy expanded. The sheet metal forming process is only recognized at the end of the hierarchy. To easily differentiate the features and the process, different color representations were used as represented in Figure 3.

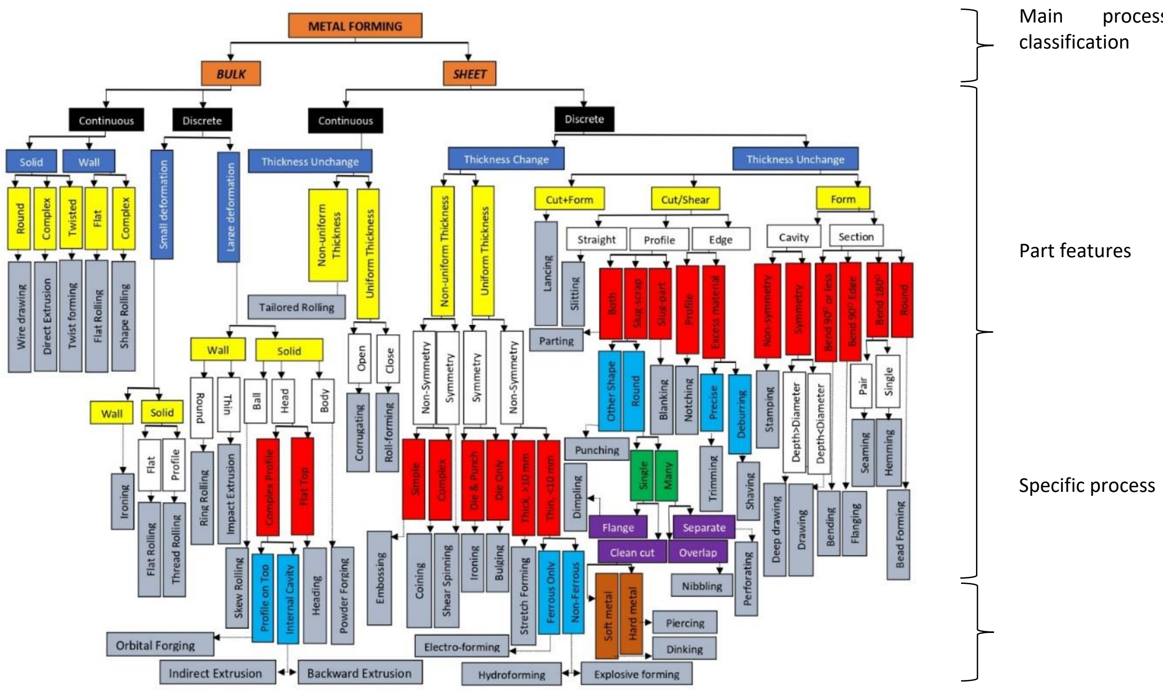


Figure 3: The template of the tool and level of details about features and process name.

Examples of the MFPT application can be seen in the Figure 4. For cut/shear feature as in Figure 6, the identification begins with the first and second characteristics of the features which is sheet metal, and the part produced in discrete. The features further expand, as the thickness may changes or not. For this case, no thickness changes. Next, the part is cut/shear, cut and form or form. This can be represented by the following sequence.

Sheet ➔ Discrete ➔ Thickness Unchanged ➔ Cut/Shear ➔ Profile ➔ slug-part ➔ blanking.

Student may name the process, as identified at the end of the flow. These steps can be repeated for each of the features recognized on the part/component. However, it is important to define a correct part feature before the process name can be identified correctly.

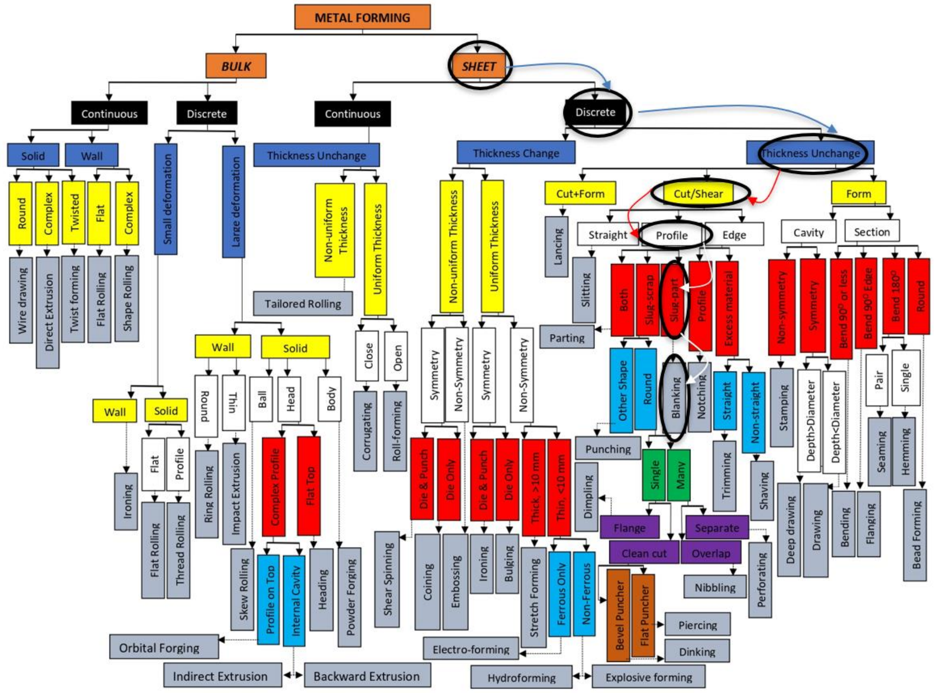


Figure 4: Example of template usage in metal forming process name identification.

CONCLUSIONS

Based on the outcomes, there are a few remarks that can be highlighted.

1. Correct identification of part features is crucial in using the developed tool.
2. Based on the survey, the tool helps students in the identification of the process name.

However, the tool is in manual mode and in the current form, it is represented by a template. Therefore, the user can identify the process name from the template.

ACKNOWLEDGEMENT

Author would like to acknowledge Universiti Sains Malaysia for the support given and to all students involve in the survey.

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