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Improvement Activities in Stamping Die Manufacturing: A Systematic Literature Review

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ABSTRACT
Die making is regarded as the mother of all industries. In the manufacturing world, this industry is thought to have existed for a long time. There is a need to address the improvement activities in this area in order to assess their relevance, results, and impacts on its latest industrial development. However, there were insufficient studies that systematically reviewed the existing literature related to stamping die manufacturing's latest improvement activities. As a result, the current article conducted a systematic literature review on stamping die manufacturing improvement activities. The present study applies the integrated multiple research design, and the review was based on the publication standard, namely the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). This research is using two leading databases, namely Scopus and Science Direct, and five supporting databases, namely Emerald Insight, IEE Explore, Wiley Online, Taylor & Francis, and Google Scholar. Using thematic analysis, this review has six main themes: design, machining, finishing, trials, and overall improvements. These six major themes were subdivided into 20 sub-themes. The findings show that the researchers are covering most of the improvements in the main elements of die manufacturing processes. Based on this study, the contribution for practical purposes of stamping die manufacturing improvements was identified. The study contributes significant findings, such as detailed improvement activities that are specific to the targeted issues but have the potential to be adapted or imitated by other practitioners and future researchers.
Keywords: Stamping Industry, Die Manufacturing, Improvement Activities.

1 INTRODUCTION

By exerting adequate power, dies are utilised to mould a component into the appropriate forms. Die manufacturing is a critical and key contributor to the success of product development [43]. Dies and moulds are common components in the fabrication of a broad variety of goods. Due to dies and moulds are required for practically all mass-produced discrete components, this industry always play a significant role in the production process [48].

The tool and die industry, which is typified by single and small series manufacturing, is now experiencing new challenges as product life cycles shorten and product derivatization increases. Tool and die makers must accelerate development and boost productivity [41]. This is in contrast to the existing lengthening of development time as a result of several recurring adjustments and improvements in conventional die production [43]. Because of the uniqueness of the goods and the constraints of the stamping production facilities, producing panels has become more complex. Job shop setups are still utilised today to create tools and dies due to the complexity and breadth of the items [5]. Low repetition rates, a high number of components per tool, and repeated interruptions in production contribute to a lack of transparency on the shop floor and time-consuming planning and re-planning [40]. The industry is also confronted with the loss of skilled labour with the with the specific specialization [5]. Because the industry is vital, there is a need for an assessment and analysis of the improvement actions carried out by other industrial practitioners worldwide.

Numerous investigations on stamping die manufacturing methods and associated enhancements, such as an improved design approach, advanced machining techniques, and finishing improvements, have been done. The research that is provided is largely industry-specific and tailored. There is a requirement to comprehend the overall picture of present operations as well as their enhancements in order to deliver insights and understandings to other

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stamping die manufacturers and industrial practitioners who are unfamiliar with this systematic investigation and its conclusions. However, there is a scarcity of systematic reviews on stamping die manufacturing, resulting in a gap in comprehending the process from a holistic standpoint.

As a consequence, the recommended strategy for comprehending the entire situation of improvements implemented in the stamping die industry is a systematic literature review. This research proposes a systematic literature review (SLR) to analyse contemporary stamping die manufacturing industry improvement actions. A systematic literature review (SLR) is one strategy for conducting a more organised review of the current literature and research. SLR is a method for separating, selecting, and evaluating past research in order to offer relevant relevance to the research question that will be formed. Prior to the review process, the protocol and sequence are discussed and thoroughly. Because the search is done across many databases, the method gives better transparency and organisation, and it will act as a guideline for future researchers to reproduce the comparable procedure and get similar findings [31]. The search strategy is extensive, and it directs the researcher in addressing the research question.

The systematic literature review approach was selected for the research over the standard literature review method, according to Robinson & Lowe, 2015, to guarantee the search is thorough, bias avoidance, and the quality justification of prior studies. The proposed review is based on a research question related to current publications on activities and methods for improvement in the stamping die manufacturing industry, with a focus on approaches, strengths, and limits. As a result, the study aims to cover the gaps left by prior research in order to thoroughly grasp the advancements and practises in the stamping die manufacturing industry.

The research makes major contributions to the stamping die manufacturing industry. Because real practises in the sector are susceptible to industry-specific issues, the research of stamping die production is seldom laid out in terms of knowledge advancement. This research also offers industrial insights on managing variation in the manufacturing process. Researchers, practitioners, engineers, and managers may obtain insight into current practises and find possible applications that might be adopted in their respective industrial domains using this study as a reference. Although the location and implementation varied greatly from one stamping die industry to the next, the fundamental and basic manufacturing processes are almost same. Furthermore, because of the same manufacturing flow, these practises may be shared throughout industries, either within a nation or across borders, opening the door for similar advances to be copied or improved. This research has the potential to offer policymakers with a comprehensive picture of what is necessary in the stamping and die industry to ensure its long-term viability in the manufacturing industry as a whole.

2 METHODOLOGY

2.1 The Review Protocol Reference – PRISMA

According to Kitchenham & Charters, 2007, since most research includes a literature review, it must be rigorous and fair, otherwise it will have less scientific value. As a result, a systematic literature review based on a preset search is necessary. The review methodology of The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) was used to comprehend the improvement efforts and the stamping die manufacturing industry. PRISMA 2009 is a strategy that was designed to help systematic reviewers by transparently detailing the review process and its findings. It has been supported by about 200 journals and systematic review organisations, and it has been used by a variety of fields. It was subsequently enhanced as PRISMA 2020, which includes reporting guidance that advance sophisticated methodologies for identifying, selecting, assessing, and synthesising research [33]. A few examples of the PRISMA method in the manufacturing area are sustainable development [28], sustainable manufacturing [35], lean manual assembly [30], manufacturing data mining [7], factory planning [10], additive manufacturing [27], manufacturing methodology [19], augmented reality manufacturing [22] and Industry 4.0 [39]. As a result, this technique is suited for systematically describing the actions and methods for improving stamping die production via searching and identification, screening, eligibility, data abstraction, and analysis.

2.2 Research Question Formulation

The objective of this article is to identify the activities and strategies for improvement in the stamping die manufacturing industry published in recent years, focusing on their approaches, strengths, and limitations. Therefore, the following research question has been selected:

Q1: What are the improvement activities in stamping die manufacturing?
Q2: What are the main strengths and limitations of the activities?

2.3 Systematic Searching Strategies

The processes involved in the systematic searching strategies are identification, screening, and eligibility.

2.4 Identification

Identification is the process of identifying and varying the keyword that is appropriate in the process of searching for articles or records for the systematic literature review. Keywords are required for the search, and they can improve the accuracy of the article or record discovered via systematic literature review references. The keyword is developed based on the research question, keywords suggested by experts, keyword use in past studies, and suggested keywords by Scopus. The list of used keywords is presented in Table 1.

The keywords were developed using search strings on the databases of Scopus, Science Direct, Emerald Insight, Taylor & Francis Online, and IEEE Xplore. Google Scholar has been included as a supporting database for the systematic literature review, as suggested by Haddaway et al, 2018. The search string and the databases are shown in Table 2. The total of 87 753 articles are found based on the search string in the database, are shown in Table 3.

2.5 Screening

The criteria will be applied to the 87,753 items chosen at the identification step. Screening is a way of selecting articles based on specified criteria that may be carried out automatically using the database's sorting function. The first criterion that has been picked is the publication date, which ranges from 2016 to 2022. This is based on research maturity, as proposed by Kraus et al, 2020, in which a sufficient number of papers may be discovered within the specified time frame. The second criterion is to prevent misunderstanding; the articles in English have been picked, and the third criterion is that the articles must provide data based on the improvement activities application rather than the application review article. The article must also be concerning the manufacturing industry, which is the fourth condition. Table 4 lists the criteria for including and excluding items. After the screening process, the result of excluded and remaining articles is as shown in Table 5.

Table 1: Searched keywords

Tool and die	Dies	Die industry	Dies Manufacturing
Die Making	Improvements	Optimization	Performance

Table 2: The search string and database

Data Base	Search String
Scopus	TITLE-ABS-KEY (("Tool and die " OR "die industry" OR "dies" OR "dies manufacturing" OR "die making") AND ("improvements" OR "optimization" OR "performance"))
Science Direct	("Tool and die " OR "die industry" OR "dies" OR "dies manufacturing" OR "die making") AND ("improvements" OR "optimization" OR "performance")
Emerald Insight	abstract: “tool and die" AND (abstract: “improvements") abstract: “dies" AND (abstract: “improvements") abstract: “die industries" AND (abstract: “improvements") abstract: “tool and die" AND (abstract: “optimization") abstract: “dies" AND (abstract: “optimization") abstract: “die industries" AND (abstract:" optimization ")
Taylor & Francis Online	[[All: "tool and die "] OR [All: "die industry"] OR [All: "dies"] OR [All: "dies manufacturing"] OR [All: "die making"]] AND [[All: "improvements"] OR [All: "optimization"] OR [All: "performance"]]
IEEE Xplore	("Tool and die " OR "die industry" OR "dies" OR "dies manufacturing" OR "die making") AND ("improvements" OR "optimization" OR "performance")

Table 3: Numbers of articles found based on search string

Data Base	Results
Scopus	49 460
Science Direct	16 764
Emerald Insight	70
Taylor & Francis Online	20 187
IEEE Xplore	1 272
Total	**87 753**

Table 4: Inclusion and exclusion criteria

Criteria	Inclusion	Exclusion
Publication timeline	2016 – 2022	2015 and before
Language	English	Other than English
Document type	Journal (research article)	Review papers and books
Type of industry	Improvements in die manufacturing industry only	Exclude improvements in other manufacturing industry

2.6 Eligibility

The eligibility step follows, in which a total of 1,395 articles are screened based on particular criteria. Because the goal of this study is to give insight into stamping die manufacturing, the article's emphasis must be on stamping die manufacturing operations and their components rather than general manufacturing activities. The duplicated article has likewise been filtered out and removed from consideration. This is a manual screening procedure that involves reviewing the title and abstract of the publications. This method removes 1 342 pieces due to the concentration on stamping die manufacturing operations. The result is as shown in Table 6. Out of 53 articles, a total of 13 are not able to access. Therefore, the total of 40 articles are finalized in eligibility process, as in Table 7. In order to ensure that the search was conducted thoroughly, a set of new keywords, which consist of specific improvements was conducted, based on industrial expert advice. The new keywords are as in Table 8. The additional search string and the databases, are shown in Table 9.

Table 5: Numbers of articles found after screening process

	Identification	Screening	
Database	**Results**	**Included**	**Excluded**
Scopus	49 460	484	48 976
Science Direct	16 764	321	16 443
Emerald Insight	70	16	54
Taylor & Francis Online	20 187	552	19 635
IEEE Xplore	1, 272	22	1 250
Total	**87 753**	**1 395**	**86 358**

Table 6: Numbers of articles found after eligibility process

	Screening	
Database	**Included**	**Eligibility Selected**
Scopus	484	3
Science Direct	321	34
Emerald Insight	16	1
Taylor & Francis Online	552	6
IEEE Xplore	22	9
Total	**1 395**	**53**

Table 7: Numbers of articles available to be access.

	Eligibility		
Database	**Eligibility Selected**	**Able to access**	**Not able to access**
Scopus	3	3	0
Science Direct	34	28	6
Emerald Insight	1	0	1
Taylor & Francis Online	6	0	6
IEEE Xplore	9	9	0
Total	**53**	**40**	**13**

Table 8: Searched key words (additional)

Automotive die	Tool and die	Project managements
Change managements	Product development	Resource Planning
Scheduling	Planning	Tool industry

Table 9: The search string and database (additional)

Data Base	**Search String**
Scopus	(TITLE-ABS-KEY (("automotive die" OR "Tool and die " OR "die industry" OR "Tool industry") AND ("project managements" OR "change management" OR "product development" OR "planning" OR "Resource planning" OR "scheduling"))
Science Direct	((“automotive die” OR “Tool and die “OR “die industry” OR “Tool industry") AND ("project managements" OR "change management" OR "product development" OR "planning" OR "scheduling"))
Emerald Insight	(("automotive die" OR "Tool and die " OR "die industry" OR "Tool industry") AND ("project managements" OR "change management" OR "product development" OR "planning" OR "Resource planning" OR "scheduling"))
Taylor & Francis Online	("automotive die" OR "Tool and die " OR "die industry" OR "Tool industry") AND ("project managements" OR "change management" OR "product development" OR "planning" OR "Resource planning" OR "scheduling")
IEEE Xplore	("automotive die" OR "Tool and die " OR "die industry" OR "Tool industry") AND ("project managements" OR "change management" OR "product development" OR "planning" OR "Resource planning" OR "scheduling")

The process of identification, screening and eligibility were conducted as the previous method. The screening and eligibility process resulted in the additional of 30 articles, as listed in Table 10. Additional database, Google Scholar also run the process of identification, screening and eligibility and using the additional keywords. The result shows additional 16 article as in Table 11. Therefore, the total articles that go through the eligibility process and redundancy removal, are 86 articles. The overall process flow of identification, screening and eligibility was shown in Figure 1.

Table 10: Numbers of articles available to be access (additional keywords).

Database	Identification	Screening	Eligibility		
			Selected	Able to access	Not able to access
Scopus	157	65	1	1	0
Science Direct	43	19	14	14	0
Emerald Insight	755	15	0	0	0
Taylor & Francis Online	754	20	2	0	2
IEEE Xplore	20	20	15	15	0
Total	**1729**	**139**	**32**	**30**	**2**

Table 11: Numbers of articles available in Google Scholar (additional keywords).

Database	Eligibility		
	Selected	Able to access	Not able to access
Google Scholar	16	16	0
Total	**16**	**16**	**0**

2.7 Quality Appraisal

Two industry professionals were given the 86 articles that had been chosen following the eligibility phase for quality evaluation. Based on the experts' assessments of the study relevance, methodology, findings, and application that were most relevant to the research topic, each article was scored yes, no, or I can't tell. This review only covers papers that were agreed upon by both experts. The procedure removes a total of 52 articles, leaving 34 articles.

2.8 Data abstraction and analysis

The next stage is to extract data from the 34 quality-assured papers. The 34 publications' iterative comparisons were synthesised and analysed using qualitative and mixed methodologies. In respect to the research topic, the abstract, results, and discussion were extensively reviewed. A table was created using information that related to the research question. The themes and sub-themes were determined using thematic analysis by detecting the pattern, similarities, relationship, and grouping [31].

The themes were developed by analysing patterns that emerged in the evaluated papers. The comparable and related topics were grouped together, resulting in a total of six themes that may be constructed. Following a thorough examination of the six themes, there are 20 sub-themes that may be constructed. The topic and sub-theme were revisited to check that the groupings were accurate and connected to the research question. Table 12 shows the names of the theme and sub-theme. Two industry experts confirmed the final development topic as appropriate and relevant to the research question.

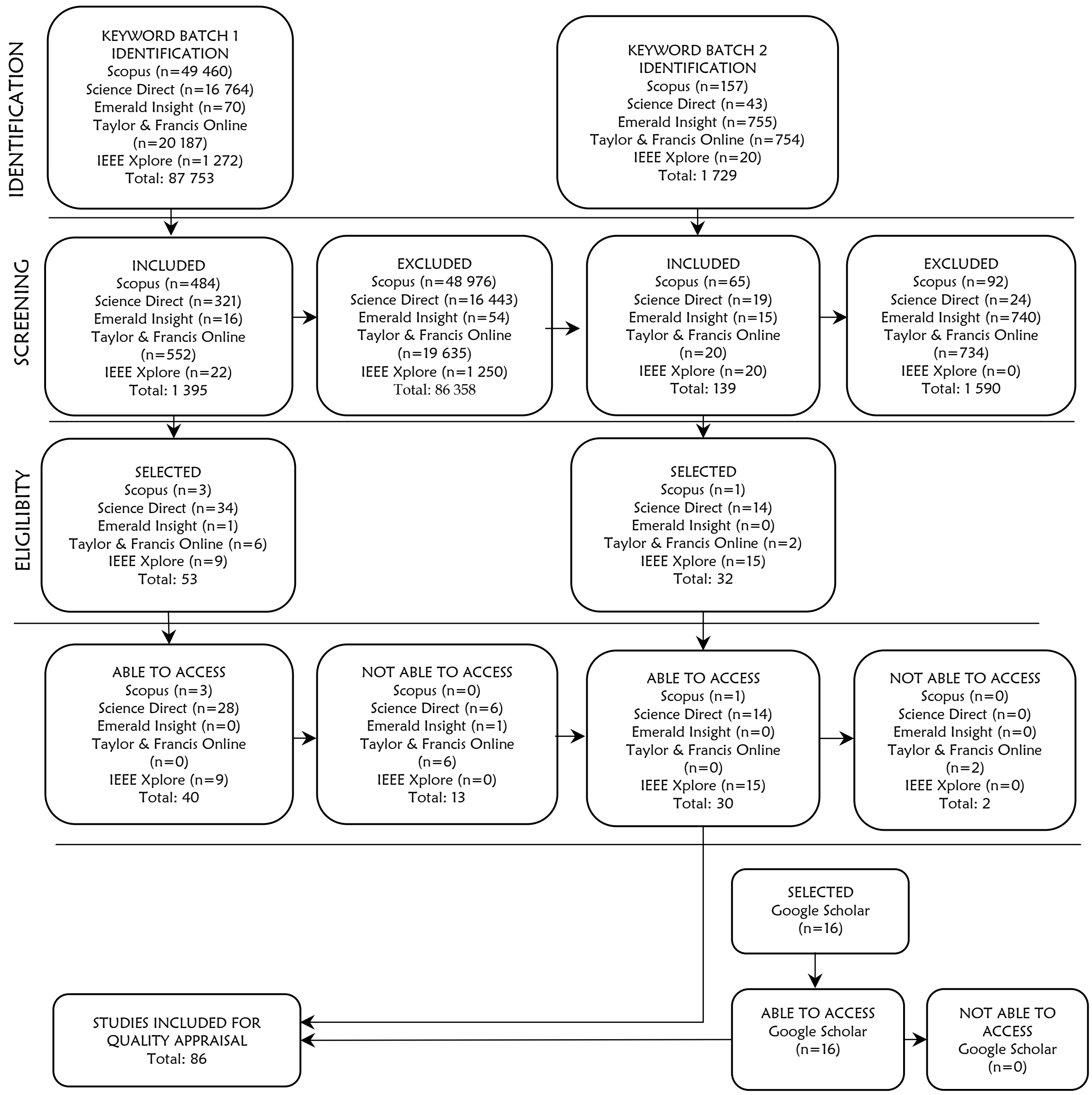


Figure 1: The flow diagram for identification, screening and eligibility process (Based on Prisma 2020)

Table 12: The theme and sub-theme

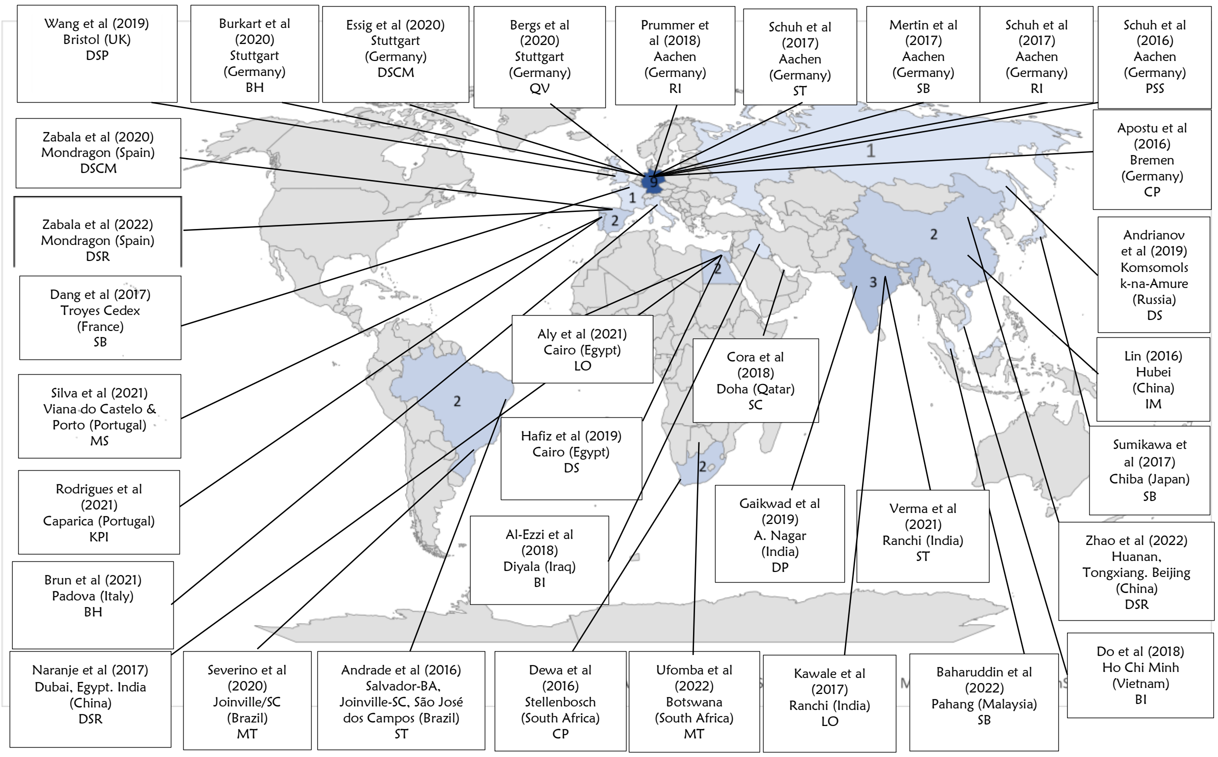
No.	Authors	Years	Region	Design			Mach.		Finishing			Trial			Quality			Overall Improvements					
				DP	LO	DS	MT	MS	DSR	DSCM	DSP	BH	SC	ST	SB	BI	QV	CP	KPI	ST	RI	PSS	IM
1	Zabala et al	2022	Spain						/														
2	Baharuddin et al	2022	Malaysia												/								
3	Zhao et al	2022	China						/														
4	Ufomba et al	2022	South Africa				/																
5	Brun et al	2021	Italy									/											
6	Verma et al	2021	India																	/			
7	Aly et al	2021	Egypt		/																		
8	Rodrigues et al	2021	Portugal																/				
9	Silva et al	2021	Portugal					/															
10	Zabala et al	2020	Spain							/													
11	Burkart et al	2020	Germany									/											
12	Essig et al	2020	Germany							/													
13	Bergs et al	2020	Germany														/						
14	Severino et al	2020	Brazil				/																
15	Wang et al	2019	UK								/												
16	Andrianov et al	2019	Russia			/																	
17	Hafiz et al	2019	Egypt			/																	
18	Gaikwad et al	2019	India	/																			
19	Cora et al	2018	Qatar										/										
20	Do et al	2018	Vietnam													/							
21	Prummer et al	2018	Germany																		/		
22	Al-Ezzi et al	2018	Iraq													/							
23	Schuh et al	2017	Germany											/									
24	Naranje et al	2017	UAE, Egypt, India	/																			
25	Sumikawa et al	2017	Japan												/								
26	Mertin et al	2017	Germany												/								
27	Dang et al	2017	France												/								
28	Schuh et al	2017	Germany																		/		
29	Kawale et al	2017	India		/																		
30	Apostu et al	2016	Germany															/					
31	Andrade et al	2016	Brazil																	/			
32	Schuh et al	2016	Germany																			/	
33	Lin	2016	China																				/
34	Dewa et al	2016	South Africa															/					

DP = Dies Process LO = Layout Optimization DS = Die Structure MT = Machining Technique MS = Machining Sequence DSR = Die Surface Roughness DSCM = Dies Spotting Colour Method DSP = Die Surface Polishing BH = Blank Holder SC = Surface Coating ST= Soft Tool SB = Spring Back B I= Burr Issue QV = Quality View CP = Capacity Planning KPI = Key Performance Index ST= Standardization RI = Resource Interlink PSS = Product Service Systems IM = Information Management

3 RESULTS AND DISCUSSIONS

A total of 34 publications were evaluated for this research. Based on thematic analysis, six topics were developed: design, machining, finishing, trial and overall improvements. The detail analysis of the six themes yields a total of 20 sub-themes. The study area mapping is shown in Figure 2.

From the 34 articles, 4 were published on 2022, 5 were published in 2021, 5 were published in 2020, 4 were published in 2019, 4 were published in 2018, 7 were published in 2017 and 5 were published on 2016.



DP = Dies Process LO = Layout Optimization DS = Die Structure MT = Machining Technique MS = Machining Sequence
DSR = Die Surface Roughness DSCM = Dies Spotting Colour Method DSP = Die Surface Polishing BH = Blank Holder
SC = Surface Coating ST= Soft Tool SB = Spring Back B I= Burr Issue QV = Quality View CP = Capacity Planning
KPI = Key Performance Index ST= Standardization RI = Resource Interlink PSS = Product Service Systems IM = Information Management

Figure 2: Research area mapping of studies related to stamping die manufacturing improvement.

Nine studies were conducted in Germany, three in India, and two in Spain, China, South Africa, Egypt, Portugal, and Brazil, respectively, from the 34 articles chosen. There was one study in Malaysia, Italy, United Kingdom, Russia, Iraq, Qatar, Vietnam, Japan and France and combination countries of United Arab Emirates, Egypt and India.

Figure 3 depicts an overview of the stamping die manufacturing die process flow from design to stamping mass production, as proposed by Donghao, 2018.

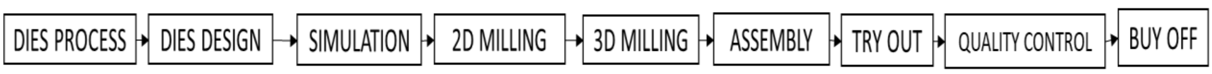


Figure 3: Dies process flow

3.1 Design Improvements

The first improvement topic in stamping die manufacturing focuses on design improvements. One of the most important processes in die development is the design process. It will affect the overall result of die manufacturing as well as the product quality generated by the die. Improvements in the die design phase are critical to producing good dies. Die process, layout optimization and die structure improvements are related sub-themes.

3.1.1 Die Processes

Naranje et al, 2017 comprehend the intricacy of the design for combination dies, which necessitates the employment of a large amount of software throughout the process. Visual Basic and computer-aided design, namely AutoCAD, were used to introduce the application of design choices to die operations and structures. The purpose of the researcher in designing the computer-aided system for the design of combination dies was to eliminate the need of several software programmes while also assisting in structural decision-making.

Gaikwad et al, 2019 were also interested in researching how to combine the die process based on initial independent die processes, as well as a strategy to minimise the die process.

The usual and original practise for these tasks was via the manual judgement of an experienced senior designer, which was the strength of both studies. By constructing the process using software, it may reduce decision error, achieve consistent findings and are able to make a solid conclusion. The decision-making process will not be confined to experienced designers alone, and younger designers may have the chance to improve their expertise of die design and procedures. Both researchers were effective in tackling one of die manufacturing's crucial procedures.

Both experiments were constrained by the fact that the systems were created particularly for the desired forms of components and processes, resulting in limited findings within the area of the planned study. For the purpose of multi-shape components and multi-operation dies, die software development may need additional growth and extension to a broad variety of applications.

3.1.2 Layout Optimization

Progressive dies are one of the die structures that have their own set of challenge. The progressive die's challenge is to optimise the strip layout, which is closely connected to the die structure and die cost [2, 23]. Kawale et al, 2017 explored progressive die tool life studies, whereas Aly et al, 2021 were interested in progressive die improvements. The development process is then linked with the die cost once the dies have been made, which is regarded one of the essential parts of sustainable die manufacturing by Kawale et al, 2017. The study's disadvantage is that it is confined to one product with a round form, hence the findings are limited, customised, and particular to the product itself.

Aly et al, 2021 use graph theory to construct and optimise the optimal strip layout for the progressive die design. The research strength is the capacity to turn the manual and intuitive strip layout method into an approach consisting of precise processes that a new designer may follow. The research's disadvantage is that creating the strip pattern design of a basic bracket involves a lengthy operation. Furthermore, based on the press machine standard, product, and scrap flow that must be followed, the strip layout design may have a few other design possibilities than those provided in the study.

3.1.3 Die Structure

Andrianov, 2019 performed finite element analysis to evaluate die structural improvements. The researchers are able to minimise die material volume while maintaining die load. Hafiz et al, 2019 used a similar strategy to improve the structure of the die via topological optimization. The primary goals were to minimise die structure, eliminate design failure, and as a result, lower die cost.

The strength of these research stems from their capacity to alter and analyse the die structure in a simulation environment, which may be capable of simulating almost similar circumstances during real try-out and production. This is a huge benefit for practitioners, who are normally concerned about the cost impact related to die structure. The research' limitation is that owing to the high cost of software investment, finite element analysis software is not generally employed by small die manufacturer. Furthermore, finite element analysis is often used in die surface adjustment. As a consequence, the use of finite element analysis in die and structure design is unique and may not be extensively applied in the industry.

3.2 Machining Improvements

Machining is regarded as the beating heart of die manufacturing. It is one of the areas where academics looked for ways to enhance stamping die manufacturing. The researchers concentrated on two themes: machining technique and machining sequence.

3.2.1 Machining Technique

Making moulds or dies is a time-consuming and energy-consuming process. It comprises a number of processes that take time and labour [46]. These researchers were seeking for ways to optimise die manufacturing time by automating integration of computer-aided design (CAD), computer-aided manufacturing (CAM), and computer numerically controlled (CNC).

Ufomba & Gadzama, 2022 study is beneficial since it employs advanced machining technique. In die manufacturing, integrating computer-aided design (CAD), computer-aided manufacture (CAM), and computer numerical control (CNC) improves machining productivity. The study is limited since these interfaces need complete functionality and appropriate software and hardware integration. This might be a difficulty for a die manufacturing firm specialising in mainly on developing nations.

According to Rossini Severino et al, 2021, rough milling was the procedure that consumed the most time in die manufacturing. These researchers were investigating ways to optimise the tool path to ensure that the machining process were carried out in the most efficient manner possible in order to save machining time.

The researcher's capacity to find the optimal tool patch for the corresponding shape during die machining is the research's strength. This study field was deemed particularly specialised since it contributes to minimising machining time. The study's shortcoming is that the findings are limited to one kind of die machining. More study on various shapes and profiles based on the provided research approach may yield different findings and have a greater impact on the analysis and benefit of machining time improvement.

3.2.2 Machining Sequence

Silva et al, 2021 machining's sequence optimization is another improvement activity. This study looked at how to enhance machining sequences by reordering them depending on comparable material type and size. This study was able to help the machining process and provide an opportunity to save machining time.

The research has a potential through die blocks machining grouping arrangements, based on the block specifications and thickness. The research's limitation is its reliance on the ability of the purchasing block to be reached in one group, CAM operator skill and software competence. This is the factor to examine whether a similar technique should be used to other sectors engaged in die manufacturing. Furthermore, this study is better suited for stamping items with a flat form and less contour.

3.3 Finishing Improvements

In recent years, researchers have focused on a few critical areas of die finishing. This is the area where most of the activities are manual and require extensive, highly skilled manpower. The sub-themes identified in this area are die surface roughness, die surface colour method, and die surface polishing.

3.3.1 Die Surface Roughness

In their studies, Zabala et al, 2022 attempted to enhance surface roughness by statistically evaluating the friction model of a few die surfaces. The researchers were seeking to determine the different impacts of surface friction characteristics on different parts of the surface. The study is able to divide the drawn surface components into particular sections that may be analysed in terms of surface friction characteristics. The study was further separated into experimental and numerical investigations, which were useful for the die manufacturing industry. However, since the research was limited to drawing dies for specific panel shape, the findings may not be relevant to other panel shapes or process. This was owing to various elements such as stamping force, heat, and surface treatments that may have contributed to the outcome.

Zhao et al, 2022 are also interested in surface roughness in relation to the panel skid line. The researchers were experimenting with surface radius changes and comparing the outcomes to simulation. The researcher is able to discover their association to the emergence of skid lines in stamped panels by altering the die contact pressure and surface draw bead radius. The study gives a reference on the cause and effect of contact pressure and the appearance of the skid line, which is useful for die manufacturers. The main constraint of the study was that it was tailored to the geometry of the panel under consideration. The work might be broadened to apply to different panel forms, providing greater context for die manufacture in general.

3.3.2 Die Spotting Colour Method

The colour picture of die spotting is the fundamental result of the die surface outcome after a trial. During die spotting, the approach entails employing colour detection using coloured paste (either blue or red, depending on country) to identify the surface performance. This method is considered to be one of the most important parts of the die-finishing process. It is used to assess the die surface's quality and performance. The activities were conducted through coating the both sides of the material and been tested through closed die [17]. Die surface colouring is one of the most challenging regions to decode. The intricacy of the outcome and conclusion are closely related to the die surface, intend panel shape and stamping parameters setting.

The colour pattern is utilised to identify local matching regions and will be enhanced by hand grinding [50]. Essig et al, 2020 investigated a comparable area, in which the colour pattern is often observed and recognised by an expert toolmaker. In both researcher experiments, the identification was translated to a numerical digital picture for standardization and shorter trial time.

Both researches attempted to create some guidelines and a numerical reference for the previously manual detecting method. One of Zabala et al, 2020's study limitation was that the simple shape was used for colour decryption. The shape may be stretched to complicated panel shapes for rich and complete results. The researcher used comprehensive scanning technologies to turn the die surface colour picture into a digital image for study in Essig et al, 2020's experiments. Because the systems are generally pricey and custom-made for the individual sector, it might be a deal breaker for die manufacturing practitioners. A simpler version should be investigated so that additional practitioners may benefit from the same findings as this study.

3.3.3 Die Surface Polishing

Die surface polishing is another time-consuming aspect of die manufacturing. Surface polishing has been done by hand from the beginning and has seen little development through the years. It necessitates the use of a highly trained die polisher with extensive knowledge in die surface polishing. Due to the requirement for the scarcity of experienced persons to perform surface polishing, Wang et al, 2019 investigated the possible application of "robot aided polishing" (R.A.P.). The goal was to automate the surface polishing process, decreasing reliance on humans and contributing to competitive production costs.

Although the study has significant uses, one of its primary constraints is the robot's flexibility in polishing complicated forms. This demands extensive robot programming and as a result, a larger expenditure. Furthermore, the researcher proposed that the robot operate alongside humans, which raises the problem of safety issues throughout the work process. To prevent mishaps during operation, the robot must be operated in isolation from humans.

3.4 Trial Improvements

Researchers were also interested in trial improvement activities. The identified sub-themes consist of blank holders, surface coatings and soft tools.

3.4.1 Blank Holder

The draw die is critical in die manufacturing for obtaining a proper panel shape. The blank holder force was a significant aspect in deciding the satisfactory draw panel outcome. Due to process obstacles such as stamping force, die structure and draw panel form, the process of stamping die trial is being done in an unpredictable state. The difficulties were to boost production capabilities by raising the blank holder's stroke rate. The force distribution was matched using experimental and numerical approaches to manage blank holder force, allowing the possibility to modify loading force throughout the trial procedure [9].

The research shows that the die blank holding force can be controlled. The limitation of this study was that the systems linked to the blank holder needed sophisticated set-up, which would present challenges when utilised in a real-world industrial context. The more complicated the arrangement, the greater opposition it will encounter when applied to the industry as a whole.

Burkart et al, 2020 investigated a similar strategy, in which the researcher adjusted the blank holder structure to increase tool endurance. The study reveals promise that should be pursued. The safety viewpoint, on the other hand, must be set out while modifying the blank holder structure. Because the dies are exposed to lengthy continuous load application, the improved structure must be meticulously built and analysed in order to withstand the continuous force.

3.4.2 Surface Coating

Cora & Koç, 2018 are curious in the impact of eight various types of coatings on the die surface. The study might be used as a reference for the surface performance of various kinds of coatings against various sorts of surface material. Despite the fact that the die material utilised in the experiment was D2, the experimental setup does not accurately represent the actual die-stamped state in the real industrial setting. This may provide outcomes that vary from the actual surface's real surface coating function.

3.4.3 Soft Tool

Due to the challenge of panel stamp uncertainty in die development, Schuh et al, 2017 proposed prototype or soft tool development prior to the development of actual dies. Its purpose is for early integration of customer requests, and were able to shorten the lead time of die manufacturing development due to the predicted results based on the soft tool.

The research provides the opportunity for application in the industry. However, by investing in developing a prototype or soft tool, the additional cost related to the prototype needs to be considered. After the actual dies are made, the prototype is usually not used, which can lead to an accumulation of unused prototypes or soft tools in the long run. The alternative application of the unused prototype or soft tool needs to be considered to ensure its maximum benefit to the practitioner.

3.5 Quality Improvements

The most important improvement area in die manufacturing is the quality area. It is related to the panel being produced by the die. The sub-theme related to the quality improvements are spring back and quality view.

3.5.1 Spring Back

Quality enhancements in panel troubleshooting the spring back issue has been the subject of many researchers. The spring back investigation of the stamped panel was the topic of Baharuddin et al, 2022; Sumikawa et al, 2017; Mertin & Hirt, 2017 and Dang et al, 2017. The researchers were comparing experimental and numerical findings to investigate the spring back behaviour of the chosen researched forms.

Baharuddin et al, 2022 performed study on the influence of various patterns, blank width, and press holding time on U-bending hat forms panel shape and die. Sumikawa et al, 2017 used both experimental and finite element analysis to perform similar spring back experiments on a curved hat-shape panel of a high-strength steel panel. Mertin & Hirt, 2017 used both experimental and numerical analysis to perform a spring-back investigation on bending and stamping parts. Dang et al, 2017 have also investigated spring-back analysis using Proper Orthogonal Decomposition (POD) surrogate models. The spring back study has a limitation in that there are no universal outcomes that can be shared across the researchers. Generalisation is difficult to achieve since stamped panels formed from dies are subjected to the desired panel criteria.

3.5.2 Burr Issue
Do et al, 2018 and Al-Ezzi & Abass, 2018 investigated improvements related to burr height reduction through design improvements and material selection using software development for piercing die. Similarly, the research is too specific to the intended problems, although it has the potential to be adapted, posing a challenge to other practitioners to imitate the same approach.

3.5.3 Quality View
Bergs et al, 2020 established the quality management model, which gives three ways to quality improvement in the tooling industry, with an emphasis on management, process, and competence. The goal is to ensure the industry's long-term viability on the global market. One limitation of the research is that it does not present an industrial example relating to the tooling or die industry.

The main constraint of the spring back, burr and quality perspective study is that no overall outcome can be shared among the researchers. Because the stamp shape from the dies is generally subjected to the intended panel, generalising the outcome is quite challenging. The ideal way is to refer to a concept, and the expected outcomes are solely specific to the particular desired experiment.

3.6 Overall Improvements
There are researchers that are interested to conduct on overall improvements of the stamping die manufacturing. The sub-theme can be divided in six sub-themes, mainly on Capacity Planning, Key Performance Index, Standardization, Resource Interlink, Product Service System and Information Management.

3.6.1 Capacity Planning
Apostu & Bendul, 2016 were interested in the connection between die cost and comparison with long-term capacity planning, and Dewa et al, 2016 were interested in preparing extra capacity during rush orders of die manufacturing through a holon shared system.

However, because capacity planning is directly related to the researcher's industry of interest, the proposed concept has the potential to be replicated but will require adaptation and improvisation to suit other die manufacturing industries.

3.6.2 Key Performance Index
In recent years, rapid technology innovation has increased competition among businesses, prompting them to seek strategies that would provide them a competitive edge. One of the ways is to use key performance indicators (KPIs) to monitor performance [37].

The precise KPIs provided by Rodrigues et al, 2021 may be comparable to those in other sectors and may vary somewhat from the research's indicated outcomes. However, the study is significant in widening the assessment of die manufacturing in general.

3.6.3 Standardization
Standardization is also essential for improving die manufacturing. Verma & Jha, 2021 and Andrade et al, 2016 are interested in developing standards and using common services across sectors.

Interestingly, the recommended breakdown items in both studies were able to resonate with other businesses in the die manufacturing industry, indicating a favourable and replicable outcome. Maximum advantage from the study results may be acquired by customising and modifying the methodology to the unique demands of this sector.

3.6.4 Resource Interlink
Prummer et al., 2018 and Schuh et al, 2017 recognise the significance of resource interlinks between die production parts. Prummer et al, 2018 investigated the relationship between shop floor and production systems. Similarly, Schuh et al, 2017 used information and communication technology (ICT) on the shop floor by displaying work in progress digitally and optimising a clear perspective of die-making shop floor activities.

The merit of both studies was that they gave guidance for possible digital system applications in die manufacturing. Because this business is regarded mature in terms of technology, a new strategy offers the door to new technological progress. However, when it comes to integrating technological innovation, cost efficiency and return on investment must be taken into account. The applications must be evaluated in terms of investment against die manufacturing sales, profit, and return.

3.6.5 Product-Service Systems
Schuh et al., 2016 conducted study on the implementation of product-service systems as an endeavour to accommodate consumer preferences and allow enhanced market competitiveness.

The researcher's method was one-of-a-kind and not relevant to various sectors. Due to a shortage of trained staff in the die service or maintenance department, some die makers are unable to offer an extension of service throughout the product's life. A typical die manufacturing business will typically have a broad variety of expertise in die manufacturing, but may not have the same amount of experience with die service and maintenance knowledge to give strong customer support throughout the die's service life.

3.6.6 Information Management

Lin, 2016 researched the last area of improvement, which is connected to a case study about the need of information management throughout the product development process to prevent any disrupted information linkage.

The researcher's method offers the potential advantage of recognising the relevance of information management in die development. However, organising and gathering important information is a barrier for this study adaption. It will need devoted, knowledgeable employees to collect, interpret, process, and manage the information gathered, as well as its storage. Without these individuals, the knowledge gathered may not be meaningful or reused by future practitioners.

4 RECOMMENDATIONS

Positive implications for the die manufacturing industry can be drawn from the 34 articles reviewed. These studies open the door to extracting the best approach from similar practises around the world. The viewpoint of similar practises can be divided into several areas of study:

4.1 Problem Statement Similarities

The majority of the concerns raised in these researches are typical in die manufacturing. This list of problems and issues may be used as a reference for future studies or other comparable practitioners in identifying the challenges they confront throughout the manufacturing process.

4.2 Methodology and Approach

Although each study has its own methodology, the overall concept and flow in the die manufacturing industry are more or less the same. By understanding the researcher's methodological approach, other researchers or practitioners are able to follow, imitate, or adapt the methodology and improve their own custom results.

4.3 Results Obtained

The findings of these 34 research are case-specific and case-based. However, the majority of the favourable outcomes are promising. Some of the study also left the door open for future researchers to pursue similar investigations in the goal of achieving comparable or better outcomes than previous studies.

4.4 Future Recommendations

There is a substantial absence of comprehensive direction or a reference handbook in the area of die manufacturing and issue solutions. Because of the custom and industry-specific character of these industry, practitioners and researchers have difficulties developing a standard process to handle issues or undertake improvement activities. The majority of the strategy is based on trial and error, human experience, or information passed down through generations.

Because of the vast complexity and sometimes non-similar components or forms under investigation, there is a requirement to build a module or reference handbook on the overall general practises that have been gathered for this die manufacturing industry. With the adoption of current technical breakthroughs, it is advised that the module or reference be separated according to certain industries, panel form, panel material and its stamping technique. Because there is now no specialised or recent guidebook that can cover the whole newest technology in improving die manufacturing, it will be incredibly valuable to die manufacturing practitioners.

5 CONCLUSIONS

The main objective of this study is to systematically review the improvement activities in stamping die manufacturing. The research makes significant contributions to bodies of knowledge as well as industrial applications. From this review, the related parties, especially the die manufacturing industrialist and researcher, may have an idea, an imitation, an extension, and an adaptation to the latest improvements that relate to die manufacturing throughout the world. The findings provide references to the most recent activities related to process improvements in a variety of critical aspects of die manufacturing. This research can detail out the improvements made in recent years using die manufacturing elements such as design, machining, finishing, trials, quality, and overall improvements, demonstrating that this area of manufacturing has a lot of potential. It provides a wide range of applications and additional knowledge to current practises through detailed analysis and issues to be solved. Interestingly, although the specific findings are different, the research concepts are relatable to die manufacturing in general and may be used as a reference and as guidance by another researcher in the same field. However, these 34 article studies have the limitation that some of the articles are not accessible, and therefore some of the improvement's activities may not be included in these studies. Better access to resources may lead to more exposure in recent activities, giving other researchers interested in similar improvements an advantage.

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