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AN EXTENSIVE REVIEW ON THE COATING, LUBRICATION AND HEAT TREATMENT USED FOR SHEET METAL FORMING PROCESS

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Abstract
In the production system, final product must be reasonably priced and has a good surface quality. The material's attractiveness is enhanced by finishing, and coatings are offered to extend the life of the product by corroding themselves and saving material from corroding. Heat treatment is utilised to make internal changes. To achieve the desired final output, high strength steel components with the requisite shapes and characteristics require a complete understanding and control of the forming procedures. Based on the various components and their interactions, this regulating parameter makes the final part attributes predictable and adaptable. Many gaps in the disciplines of forming-dependent heat treatment, lubrication, and material coating were discovered after a study of existing research. In this study, importance of all three-sheet metal forming processes were discussed. The study aims to give background information on the forming process while also demonstrating the great potential for future research and innovation in the disciplines of lubrication, heat treatment, and material coating in sheet metal forming.
Keywords: Coating, Lubrication, Heat Treatments, and Sheet Metal.

I. Introduction

Coating is a type of surface coating that may be applied to an item, such as sheet metal. The purpose of coating application is to raise the value of sheet metal through upgrading its display, resistance to corrosion, scratch and wear resistance and other characteristics. Coating or layering methods involve applying a thin layer of a functional substance on the sheet. This functional material may be organic, inorganic, metallic, non-metallic, solid, liquid, or gaseous in state. These are some of the most regular coating classifications. Heat treating (or treatment) is the process of changing the physical, mechanical, microstructural, and occasionally chemical properties of a material. It includes techniques like as annealing, tempering, case hardening, and others. Heating and cooling occur often accidentally during other manufacturing processes, such as hot shaping or welding, influencing the material's properties. Lubricants are liquids or powders applied to sheet metal to lower the friction and damage between the tool and work piece. Decreased abrasion between the tool and the workpiece decreases the generation of high temperatures, which improves workpiece qualities such as surface roughness and dimensional accuracy. The lubricant is applied as a fine layer before working on the sheet metal. To ensure uniform component part manufacturing, it must be reapplied on a regular basis.

2. Various effects on sheet metal operations

2.1 Effect of Heat treatment

Kondratiuk et al. [1] investigated the phase evolution and microstructure of heat-treated zinc coatings. The researchers concluded that discontinuous heat treatment on manganese boron steel was a viable technique for evaluating microstructural changes inside the coating. When an electroplated Zn-Ni coating is applied, it creates a single phased microstructural arrangement which is intermetallic. When compared to hot zinc layers, this Zn-Ni coating makes its melting point higher. The moment when the complex is intermetallic and devising primary solid solution inside the heat-treated layers are investigated, the presence of nickel produces considerable alteration. Because endothermic phase shifts require heat absorption, which lessens the thermal gradient, heating properties influence phase development and vice versa. For hot sheet metal forming applications, this coating of single phased intermetallic alloy is appropriate due to their outstanding thermal stability and unique solid alloying method. Loganathan et al. [2] investigated how heat treatment using microwaves affected the characteristics of AA6061 sheet metal especially the mechanical properties. Employing heat treatment process using microwave, equivalent heat transfer is found due to volumetric heating all over the surface of sheet metal, and the specimen did not bend during processing, unlike in classical heat treatment. The presence of eutectic precipitate implies that the heat-treated material's hardness has increased. Shorter heat treatments enhance tensile and yield strength. Manesh et al. [3] looked into how annealing affected the mechanical characteristics of a sheet made up of aluminium -clad steel. It is analysed that the extent of the intermetallic phase developing at the planes of steel and aluminium layers is enhanced, when the annealing temperature gradient is elevated up to 500 °C over a sustained interval of time. The most favourable annealing condition is 450 °C for 16 hours because the solidifying effect generated by passing the metal through rollers below its recrystallisation temperature is removed. The intermetallic phase width of the interphase between the aluminium and steel is lowered when compared to other annealing settings.

Lee et al. [4] studied how annealing affected the interfacial and mechanical characteristics of sheets made of copper clad metal, stainless steel and aluminium. At the point where the Cu and Al plates meet for the tension test using heat treatment, a composite layer forms at a high temperature of roughly 400 °C. In a Vickers indentation test, the MA annealing affix phase, Al_2Cu, displayed brittle behaviour. The intermetallic composite layer was so thick and fragile that it reduced the clad sheet’s elongation at 400 °C.

Manesh et al. [5] examined the sheet of aluminium-clad steel for finding its formability along with the bond strength. The researchers arrived at the conclusion that annealing duration at a constant annealing temperature is closely connected to the formability of an Al-clad steel sheet. Annealing duration and temperature have impact on Al-clad steel by altering its bond strength. The bond strength and highest formability are found in sheets of Al-clad steel that has undergone annealing for 16 hours at the temperature of 450 °C.

Garret et al. [6] to produce sheet components of AA6xxx, looking at the feasibility of cold die quenching as well as solution heat treatment. According to the findings, the new approach is practicable. Even at room temperature, cold die quenching produced enough quenching to preserve the single phased material (Supersaturated Solid Solution). The kinetics of aging are influenced by the relationship between the quenching rates and preformation. Deformation at this stage is helpful because it lessens the material's quench sensitivity, making the process simpler

. Gau et al. [7] studied the spring back behaviour of brass during the production of micro sheets. The traditional notion of spring back could not be used when the thickness of the brass sheet metal was less than 350m. Springback in micro sheet production can alternatively be described by the T/D ratio rather than the thickness.

In the process of formation of sheet metal, the use of flexible sheet metal enrolled form was studied by Kopp et al. [8]. Therefore, the two available production techniques, "Flexible Rolling" and "Profile Strip Rolling," may produce load-adapted blanks. Mixing both the production procedures "Flexible Rolling" and "Strip Profile Rolling" is another possibility. Moreover, adequate research has not been done on the production of tailor-rolled blanks composed of magnesium and aluminium.

Salandro et al. [9] used pulsed current to test the formability of al 5xxx sheet metals following various heat treatments. The material 5083 aluminium alloy was shown to have the largest gain in formability because of the electric pulses. The formability of the 5052 aluminium alloy was increased by electric pulsing, although not as much as the formability of the 5083-aluminium alloy.

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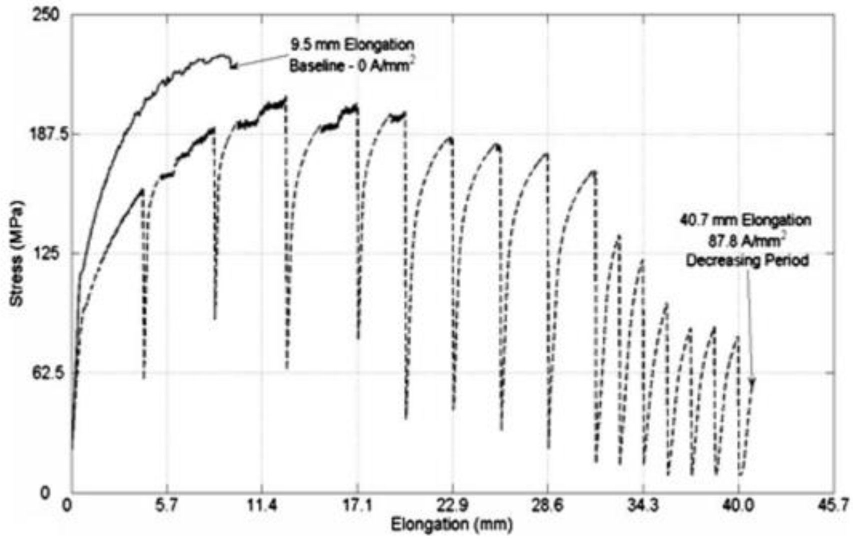

Figure 1: 5754 Aluminium with decreasing pulse period [9]

Golovashchenko et al. [10] examined a double step method for fabricating complex sheet metal structures. The researchers concluded that a double step forming strategy had been studied to augment the capabilities of conventional mechanical stamping for components with acute radii and large gaps. Microstructural analysis reveals that at lower temperature, shear band formation takes place, where fractures may emerge, subsequently come together to form macroscopic cracks that break as the load increases. Compression tests subjected to initial heat treatment reveals superior deformation resistance than non-heat-treated isothermal testing at temperature gradient of 600 to 800 °C. The opposite conduct is found above 900 °C.

The study conducted by Yumi Choi et al. [12] examined the peak-aged and W-tempered 7075 alloy steels of aluminium for its spring back, formability, and the mechanical properties. They found that the plastic deformation anisotropy of the 7075-WT sheet was significantly greater than its strength anisotropy, and it was comparable when seen relative to that of 7075-T6 sheet before the process of heat treatment. The Bauschinger effect was significant in anisotropic hardening, and the easing of monotone and reversed flow over time was observed. In comparison to the initial Young's modulus, the 7075-WT sheet exhibited only small stresses and a 10% reduction in the visible elastic constant. The distortion-based HAH model successfully predicted the anisotropic hardening behaviour of the 7075-WT sheet, and the results of the formability tests were more in line with the revised Swift hardening rule.

According to Chechen Li et al. [13] investigation into the microstructure and qualities of hot stamping steel of boron using various holding times and heated dies, materials with diverse mechanical properties may be produced by employing temperature-controlled hot stamping moulds. The holding time may be changed to change the materials' hardness, which ranges from 280 to 455 HV. The groundwork for true commercial manufacturing is laid here. At the macro level, lengthening the holding period lengthens the material's elongation and tensile strength. This means that as the holding period grows, so do the plastic properties of the material. The phase volume may be computed using a colour tint and SEM combination etching techniques to comprehend the microstructure of the materials. Building on the assumption that the variation in martensite volume is proportional to the macroscale variables, constitutive models based on holding time may be created. Overall, this experimental approach can assist in the development of constitutive models for future material manufacture with desired mechanical properties.

Souad Ayadi et al. [14] examined how manganese steel's microstructure and wear behaviour were affected by its heat treatments and chemical composition and summarized that the microstructure of heat-treated steel is composed of martensite, residual austenite, and a few precipitates. The addition of niobium and chromium components increases the steel's hardenability, allowing martensite to develop.

Martensite is a hard, brittle steel phase formed when austenite, a high-temperature steel phase, is rapidly cooled. By heating to a high temperature and then quenching it with water, austenite is partially converted to martensite. This is because to the rapid cooling generated by water quenching, which helps to change some austenite into martensite. Retained austenite is a metastable phase of steel that can increase the toughness and ductility of the material in specific applications. Nevertheless, too much austenite can create dimensional instability and poor wear resistance. Precipitates can also have an impact on steel characteristics by acting as strengthening agents or by improving corrosion resistance. Overall, chromium and niobium additions, as well as high-temperature heat treatment followed by water quenching, are efficient ways for improving steel hardenability and encouraging martensite development, which can boost the material's strength and wear resistance.

2.2 Effect of Lubrication on Sheet Metal Operation

Rahmati et al. [15] undertake studies to illustrate the benefits of employing nanoparticles instead of lubricants, which are less harmful to the environment and increase machining performance. According to the Taguchi optimization technique, utilizing 1 wt.% nano-particle would reduce cutting forces, 0.5 wt.% nano-particle concentration in mineral oil would result in a minimal cutting temperature, and an optimal surface could be achieved. To enhance the machining process, a modest amount of lubricating oil mixed with a nanoparticle addition is all that is necessary. Azevedo et al. [16] perform studies and discover that using the right lubricant enhances surface finishing, decreases forming forces, and, most significantly, extends tool life by minimising tool wear. AL-M lubricant along with SAE 30 performed well while forming AA1050 sheet components. While creating DP780 steel, AS-40 lubricant along with Finarol B5746(oil) performed well. The findings additionally help to establish the relationship linking the lubricant viscosity utilized in final roughness and the material hardness. Bay et al. [17] Begin a series of tests for sheet metal forming friction and lubrication, and utilise the previously developed test equipment to evaluate a variety of lubricants in a variety of methods utilized in production of sheet metal. Proper lubricant selection in the making of metal sheets assists in cost saving. They talk about an EU group endeavour to create more environmentally friendly lubricants to replace harmful ones.

Fiorentino et al. [18] investigated how an appropriate lubricant friction coefficient may affect the THF process. Six different types of lubrication conditions were used in the test. When Teflon was employed as a lubricant, the finest output in level of thickness and bulge height were secured, while the best results in terms of surface finishing were obtained when no lubrication was utilised.

Gong et al. [19] shown experimentally that PE film is the best lubricant option in micro deep drawing. It has the highest limit drawing ratio (LDR) and the smallest fmax. Evaluation of lubrication conditions included none, castor oil, soybean oil, as well as PE film. Under all the lubrication settings, the manufacturing of micro cups served as the foundation for the result.

Hussain et al. [20] As a result, organic lubricants are incompatible with the gradual formation of the CP Ti sheet. It is possible to use a lubricant prepared from a 4:1 combination of jell of white petroleum mixed with powdered MOS_2. This combination yields an allowable surface quality. It does not operate effectively in the absence of additional lubrication on the covered surface. As a result, the needed lubricant must be applied to the surface coating of the blank.

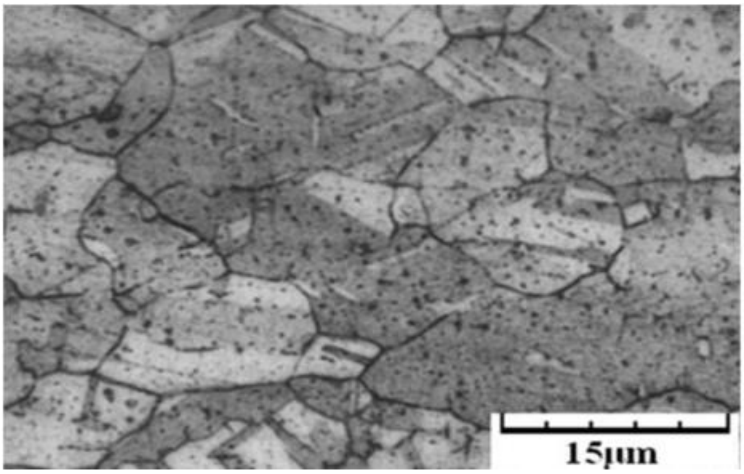

Figure 2: LSCM Grain images of specimens after annealing [19]

Kim at al. [21] using ironing along with deep drawing techniques, stamping lubricant's efficacy was assessed. The studies showed how different stamping lubricants performed with contemporary high strength steels in almost every production situation. Of the six types of lubricants tested, polymer-based lubricants along EP additive (lubricant 1) and lubricant 2 (polymer -based lubricant with EP addition) were the most efficient. Lovell et al. [22] furthermore, in terms of components sheet surface characteristics, overall sheet formability, and the observed coefficient of friction, canola oil along with boric acid performs better than the competition. Our research indicates the canola oil lubricant with acidum boricum shows significant promise for offering the industrial sector a financially feasible and, more importantly environmentally benign alternative lubricant that permits the construction of sophisticated machinery.

Table 1 : Surface roughness parameters obtained using various lubricants

Initial surface roughness			Final surface roughness	
Ra (μm)	Rm (μm)	Lubricant	Ra (μm)	Rm (μm)
		Dry	0.70	3.32
		Canola Oil	0.67	5.47
0.40	1.03	Transmission Oil	0.65	7.25
		Canola Oil and Boric acid	0.58	4.70

Ngaile et al. [23] and colleagues and he find in his study that the die of pear shape (48 c) produced the suitable results for construction of a test model for tube expansion. The corner fill measurement, wall thickness, bursting pressure and final corner radius can all be used to get the apparent friction coefficient. If the pressure created at the interface is equivalent to that in THF operation, the limiting dome height test finite element analysis showed that the technique is extremely sensitive. Evaluation of performance of lubricants and die coating for the transition zone can be done using this method. Under the same working conditions. Meiler et al. [24] compared the lubricities of boric acid to those of several commercial lubricants (Combination of graphite oil, MoS_2, PTFE). For three aluminium alloys (1100,5052, and 6111), the results of deep drawing tests demonstrate that the boric acid layer's lubricity is comparable to that of routinely used commercial lubricants and excellent throughout a broad range of forming speeds. Moreover, SEM images show that after boric acid lubrication, the distorted surfaces are free of any visible scratches. Because boric acid coatings are more water soluble and less hazardous than other coatings, they should make post cleaning of manufactured components simple and secure. Xie et al. [25] conclude from their experiment that the nano-MoS_2 or nano-SiO_2 along with base lubricant has greater lubrication capabilities when compared to the base lubricant of AZ31 magnesium alloy/steel connections. The perfect concentration of nano-MoS_2 was 1.0 wt.%, whereas the best nano-SiO_2 concentration was 0.7 wt.%. The inclusion of nanoparticles can improve the basic lubricant's load bearing capacity. Due of the strong pressure impact, the beneficial effect of nano-MoS_2 is more visible at elevated contact pressures than it is for nano-SiO_2. The lubrication layers breaks through roughly 230 and 2600 sliding when the basic lubricant and SiO_2 nano lubricants, respectively. At the beginning of the test, the coefficient of friction is slightly greater than that of nano-SiO_2, but gradually drops and stabilizes at the decreased value than that of the basic lubricant near the end of the test. According to Zhan et al. [26], the good tribological characteristics of the composites are attributable to a graphite rich tribo-layer produced on the worn surface. The proportion of C coverage for the composite increased as the Gr (Graphite) content in the composites increased, which reduced wear loss and the sliding pair's friction coefficient. Using field emission SEM, nano graphite particles are discovered to be affixed to the uppermost worn surface layer. By adhering to the contacting surfaces and the worn debris, these nanoparticles took part in the mechanical mixing process. As a result, the optimum technique to achieve low wear loss and consistent friction was to develop a nongraphite to nano graphite contacting mode. Making the use of the microcrack propagation R local delamination approach, the tribolayer failure mechanism was developed.

Meghshyam Shisode et al. [27] validated the Mixed Lubrication Friction Model for Sheet Metal Forming with Surface Texture Effects and concluded that it is a valuable tool for predicting and optimizing the behaviour of forming processes. The model correctly reproduces the fluctuation of the friction coefficient by accounting for local contact circumstances, lubricant characteristics, and material behaviour. Therefore, the model may be used to calculate the optimal lubricating conditions for reducing friction and improving formed product quality. Because it considers both solid-solid asperity contacts and hydrodynamic lubrication, the model can correctly forecast the behaviour of both mixed and border lubrication regimes. This is critical because the amount of lubricant used in a forming process might change and hence affect the friction regime. The model may better predict process behaviour and optimize the quantity and kind of lubricant used by correctly capturing this transition. Validation with both FE simulations and experimental data further supports the model's validity and utility in real-world scenarios. Engineers and researchers may use the new mixed lubrication friction model to better predict and optimise the behaviour of forming processes, resulting in improved product quality and process efficiency. Use of $CaCO_3$ in Sheet Metal Forming processes as a green lubricant was studied by lfar Arinbjarnar et al. [28] and summarised that when used in sheet metal forming, the addition of calcium carbonate particles to lubricants can boost their wear resistance. The characteristics of the lubricant (anti- frictional) were unaffected by the addition of $CaCO_3$ particles with a size of 40 nm or 2 m at concentrations ranging from 0 to 11 weight percent. The Particle-on-Disc (POD) test is another method for determining the lubricating efficiency of additives in sheet metal forming. The results of this test indicate that smaller particles with a diameter of 40 nm can aid in the stabilisation of surface contact betwixt the workpiece and the tool during formation of sheet metal. Since smaller particles may cover microscopic gaps and irregularities in the contact surface, they reduce friction and wear. Overall, including calcium carbonate into lubricants can aid in the improvement of lubricant wear resistance during sheet metal forming. Yet, the efficacy of this addition is altered by various factors such as particle size, concentration, and application conditions.

For deep drawing operations, Mathias Liewald et al. [29] investigated the characterization of a new aerostatic lubrication system and summation that this study makes a fresh suggestion for creating a dry sheet metal forming procedure that makes use of an aerostatic lubrication system (ALS). The study's purpose was to determine whether this ALS was suited for lubricant-free deep drawing and to identify the key factors influencing the system's friction conditions. Liquid carbon dioxide and gaseous nitrogen were the investigation's intermediates. Basic tests were conducted initially to determine the primary causes of ALS, which were subsequently thoroughly investigated. The results showed that the pattern and design of the micro-holes on the active tool surfaces as well as the pressure of the volatile medium supply had a substantial impact on the amount of gaseous lubricant pressure in the gap between the sheet metal material and the tool. This changed the actual contact surfaces of the friction partners, which led to varying friction coefficients. Eventually, improved strip drawing experiments were used to collect the friction coefficients, and for the new ALS an empirical friction model was constructed to enable accurate prediction of the friction coefficients. Overall, the results demonstrated that an ALS can be a technically feasible, lubricant-free option for sheet metal forming processes, with the potential to reduce costs and environmental effect.

2.3 Effect of Coating

Tsai et al. [30] investigated two-step phosphate/molybdate passivation for hot-dip galvanised steel sheet passivation. They discovered the following: Roll coating with Zn phosphate solution yields mostly Zn phosphate with trace quantities of Mg, with an uneven, porous, and amorphous coating thickness.The absorbed MoO_4 and PO_4 anions held chloride ions at bay throughout the salt spray test. Yu Su et al. [31] shown how additives impact the phosphate alteration coating properties on electrogalvanized steel sheets. They observed that by adding Ni^2+ and Mn^2+ ions to the phosphate solution independently to control the porosity of the phosphate modified coating on electrogalvanized steels, they could reduce particle size and sponginess while boosting corrosion resistance. Zn decreased the Ni^2+ concentration in the solution, boosting Zn solubility and the formation of hoplite grains. The presence of Mn^2+ in the fluid enhances nucleation by increasing reactive breach. Chemical composition of phosphating bath listed below.

Table 2: The chemical composition of the phosphating bath.[31]

	Composition (mmol/L)				
Label	H_3PO_4	ZnO	$NaNO_3$	Ni $(NO_3)_2$	Mn $(NO_3)_2$
Phosphated without Ni2+ and Mn2+	220.0	18.4	235.3	-	-
Phosphated with 8.5 mmol/L Ni2+	220.0	18.4	218.3	8.5	-
Phosphated with 17.0 mmol/L Ni2+	220.0	18.4	201.3	17.0	-
Phosphated with 34.0 mmol/L Ni2+	220.0	18.4	167.3	34.0	-
Phosphated with 8.5 mmol/L Mn2+	220.0	18.4	218.3	-	8.5
Phosphated with 17.0 mmol/L Mn2+	220.0	18.4	201.3	-	17.0
Phosphated with 34.0 mmol/L Mn2+	220.0	18.4	167.3	-	34.0

Schiller et al. [32] investigated innovative EB PVD coatings on iron sheets and layers. They discovered that the SAD approach produced high density Ti coatings that were also corrosion resistant. As compared to non-activated coatings, plasma activation of the HAD method may result in two to three times the hardness and chemical resistance of Al_2O_3 coatings. Annealing followed by evaporation of a thin iron layer over hot-dipped steel may result in the development of new and improved properties. Amadeh et al. [33] investigated the influence of rare earth elements on the surface morphology and corrosion resistance of hot-dipped zinc coatings. REM can be utilised in a variety of ways to improve the corrosion resistance of hot-dip consumed steel. Asgari et al. [34] conducted an experimental investigation of the structure, corrosion resistance, and morphology of hot-dip galvanised zinc coatings. Increasing the lead level in the zinc bath resulted in a 0.2 reduction and a 20.1 increase in both skin passed and non-skin passed specimens. The ratios of non-skin-approved specimens were greater at 20.1 and reduced at 00.2. The corrosion resistance of both types of specimens rose when the 0.2 and 20.1 value fell. As compared to non-skin passed specimens, skin passage reduces corrosion/polarization resistance. The presence of basal plain at the surface reduces as the lead content of the zinc rain rises. Berchem et al. [35] looked at the fatigue behaviour of two hot-dip galvanised car body girds, one with and one without pre-straining. They eventually came to the following conclusion: The HS IF steel outperformed the C-Mn steel in terms of high-cycle fatigue performance, which might be attributed to its slightly higher yield strength. In general, a material's fatigue life in air grows roughly proportionately to its yield and tensile strength. If the decreased deep draw ability of C-Mn steel is considered, it can be used in place of HS IF steel.

F.Berto et al.[36] investigated the effect of hot-dip galvanization on the fatigue behavior of welded structural steel , While some results of fatigue tests performed on unslotted specimens are available in the literature, very few of them address notched components, and none address welded joints as far as the authors are aware. This information gap is somewhat addressed by the present study. Koltsov et al. [37] investigated the wetting and laser brazing of copper-silver filler metal on zinc-coated steel products. They observed that the Copper-3 wt.% Silver welded alloy did not moisten bare or Zn-coated steel objects promptly. The presence of iron oxides on the bare steel exterior prevents wetting. The meeting angle of the EG and GI coatings reduces to 20-40 depending on the kind of Zn coating after a brief period of zero-reactive wetting. The reduction in nanometric zinc and aluminium oxide thickness and eviction of zinc coating, as well as the creation of a micrometric layer of iron silicide at the interface, all contributed to the increased brazing capacity of the GI and EG products.
According to laser brazing study, the effect of brazing energy on procedure window width is related to the higher brazing ability of GI and EG products (wider process window) as compared to bare steel. In their examination, Kondratiuk et al. [38] disclosed their findings on the erosion and wear style of coatings for hot sheet metal forming. They observed that different surface conditions and chemical states following heat treatment affect the tribological performance of Al-Si and Zn-Ni coatings. The researchers discovered that electro-plated Zn-Ni coatings exhibit lower coefficients of friction than Al-Si coatings due to the creation of a thick zinc oxide top layer during heating. Additionally, as compared to an Al-Si coated pattern, the study discovered that significant ZnO production is responsible for increased workpiece wear. Utilizing Al-Si coated blanks and heating the boiler to 920 °C helps to reduce sticky wear. When Zn-Ni coated blanks form zinc oxide layers, the amount of pure metallic coating material on the die is reduced-Coated Hot Stamping Steel Liquid Metal Embrittlement was examined by Lee et al. [39]. They discovered that annealing prior to hot stamping accelerated embrittlement by transforming Fe-Zn intermetallic complexes into a Zn-rich liquid phase. This is because the matrix grain boundaries were quickly wetted. Tensile stress-induced grain boundary decohesion causes large surface cracks. By increasing the austenization period, which prevents liquid Zn from diffusing through the surface of totally coated 22 MnB_5 steel, a strong Zn-in-a-Fe solution is produced.

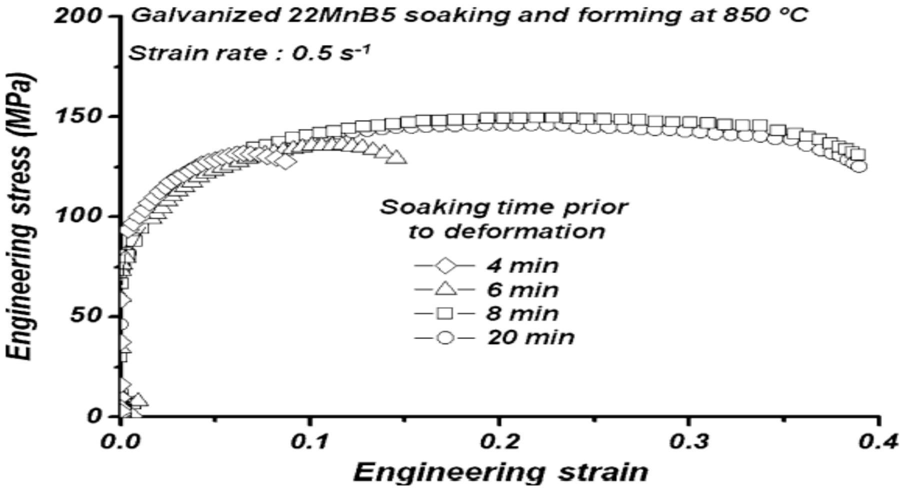

Figure 3: Engineering stress-strain curves of the Zn-coated steel on different time durations[39].

Jin-tang et al. [40] investigated the formation and degradation of a rare earth layer on hot-dip galvanised steel. They observed that soaking hot-dip galvanised steel sheets in an aqueous cerium nitrate solution might result in rare earth coatings. The clump of the film expands as the analysis time rises, but the film's mass gain stays constant. Around the zinc grain barrier, the film thickens quicker and is more prone to break. The coating cloaks and peels off as its thickness increases. Corrosion determined by its thickness and fractures. Corrosion reluctance rises initially and then reduces as treatment duration increases. Safaeirad et al. [41] studied the formability and mechanical setting of hot-dip galvanised sheets, as well as the influence of microstructure and texture. Based on their observations, they came at the following conclusions: When the lead content in the zinc shower increases, size of the coating expands. The texture coefficient of the (0 0 2) basal plain basic and the formability of hot-dip galvanised zinc coatings decline as lead concentration increases. The zinc bath's lead component lowered the formability parameter rn. When FLDs for several samples are compared, the values of FLDs enhance as the lead level of the zinc bath increases. Gamma veneer's formability decreases as its thickness grows. Song et al. [42] investigated the relationship between the microstructure of hot dip galvanised zinc coating and two-phase steel adhesion. The zinc polishing for DP steels is made up of a zinc slab and columnar f-$FeZn1_3$ particles suspended over a thin inhibitory layer near to the steel component, they discovered. The inhibitory layer is formed of sliced lenticular g-Fe_2Al-xZnx particles that are put on top of a thin solid sheet of lenticular g-$Fe2Al_5$-xZnx particles. Prior to the deposition of zinc coating on the steel surface, it was separated and oxidised. When Mn oxide meets the zinc coating or inhibitory layer, the interfaces fracture, causing cracking at the zinc grain boundaries.

Hang et al. [43] demonstrated the essence and metal transfer nature of the brisk metal transfer (CMT) arc, as well as its use in the attachment of aluminium to zinc-coated steel. They saw that the CMT metal transfer method was rather stable, so they adjusted the arc heating behaviour using wave curb characteristics and a back-drawing strength assister. Incompatible metals such as aluminium and zinc-coated steel sheet may be bonded in a lap joint without breaking thanks to the CMT process. In the compound layer between steel and weld metal, the Fe_3Al_5 and $FeAl_3$ phases coexist. To ensure joint strength, the density of the intermetallic composite veneer can be lowered to less than 5m. Jeremias et al. [44] concluded that the creation of sorption-based heat transformation via a metal covering was investigated using a very stable, hydrophilic aluminium fumarate MOF. AF, on the other hand, may be used completely under genuine, isobaric working circumstances due to its MP-hydrophilicity. At a relative tension range of 0.2 ($p/p_0 = 0.35$), the isotherm of AF displays a characteristic, steep s-shape, which has not been seen in more water-stable MOFs. The use of aluminium salts (E520-523), as well as other fumarates, as food additives has been permitted by the EU (E365-368 produced on a metallic substrate using the thermal gradient technique, clearing the path for its implementation. The material's

shown hydrothermal support for 4500 adsorption/desorption cycles makes it appealing for several applications such as catalysis and petrol depot.
Huaiyin chen et al [45] working on mof based superhydrophobic composite to generate a superhydrophobic composite coating, ZIF-8 nanoparticles were modified with a low surface energy POTS and combined with an EP coating. The resulting ZIF-8/POTS/EP coating demonstrated exceptional water repellence with a water contact angle of up to 168.2º, as well as outstanding endurance and resilience in the face of various challenges such as pH changes, sandpaper abrasion, weathering, and salt solution immersion. Because of these characteristics, the composite coating is particularly suitable for a wide variety of applications. The self-cleaning, anti-pollution, superior corrosion resistance, anti-icing performance, and loading-increasing qualities of the ZIF-8/POTS/EP superhydrophobic coating are only a few of its remarkable properties. Even after 100 tests, the coating can effectively resist contamination from dye-contaminated water, has an impressive impedance modulus despite immersion in 3.5 wt.% NaCl aqueous solution for 7 days, and can cause supercooled water to freeze outside of its surface without losing its super hydrophobicity. Also, the coating can boost the carrying capacity of a porcelain boat by approximately 63.5% of the hull weight. This research shows a feasible way for improving the performance and broadening the use of superhydrophobic coatings and MOF materials. Hen Yu et al. [46] works on porphyrin based coating The coating was created using a physical adhesive method, and the finished product demonstrated excellent heat stability, lifespan, and extraction efficiency. This was due to the massive surface area, porous structure, and conjugated system. Headspace solid-phase microextraction (HS-SPME) technique provides a broad linear range, low detection limits, and excellent repeatability and reproducibility. With excellent recoveries, the approach was successfully applied to the measurement of polycyclic aromatic hydrocarbons (PAHs) in water and soil samples. PAHs were identified in soil and water samples. The porphyrin-based COF coating, according to the researchers, has significant potential as an adsorbent for the study of molecules with complicated conjugation structures.
M. Golabadi et al. [47] studied on the Corrosion behaviour of zirconium-pre-treated/epoxy. The addition of zinc sulphate to the Zr-based conversion coating improved the corrosion resistance of the steel substrate by increasing surface roughness, surface free energy, and the creation of an inhibitor layer, which operated as a barrier against corrosive agent diffusion towards the interface. The study also discovered that applying a Zr-based conversion coating as a pre-treatment increased the anti-corrosion properties of epoxy coatings while decreasing the cathodic disbandment rate over time. The addition of zinc sulphate to the coating boosted the protective efficacy of the epoxy coatings, notably against scratching, by generating a denser structure. Overall, the study discovered that Zr-based conversion coating with additives might be a viable pre-treatment for improving the anti-corrosion characteristics of epoxy coatings on steel substrates.

II. Conclusions

In conclusion, sheet metal forming is a widely used manufacturing process for producing complex and precise metal components. However, the process could be challenging due to the high stresses and strains involved, which can lead to defects and damage. The use of lubrication, heat treatment, and coating had been investigated as a means of improving the performance of sheet metal forming. Lubrication had shown to reduce friction and wear during forming, resulting in improved surface finish and reduced tool wear. Heat treatment can be used to increase the ductility and formability of the metal, enabling more complex shapes to be formed without cracking or failure. Coating could also be used to reduce friction and wear, as well as to provide additional protection against corrosion and other forms of degradation Overall, the use of lubrication, heat treatment, and coating in sheet metal forming can improve the process efficiency, reduce defects, and scrap, and improve the quality and performance of the finished components. However, the optimal selection and application of these techniques depend on the specific materials, process conditions, and desired outcomes. Further research was needed to fully understand the mechanisms and effects of lubrication, heat treatment, and coating on sheet metal forming, and to develop more advanced and effective solutions for this important manufacturing process.

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