

New Challenges to the automotive fasteners and cold formed parts in the chinese markets

Jin Guang Chen, Zhi Xian Zhang, and Chee Mun Choy^a

Ritai (Shanghai) Auto Standard Component Co Ltd.

Abstract. Despite of substantial cold forming related R&D, innovations and new inventions have been achieved and reported by research institutes and famous industrial organisations, many small and medium size enterprises in the third world or developing countries considering this R&D activities is too luxury. Most of the third world cold forming factories still dependent on previously successful experiences by using trial an error methods. The author does not make attempt to write a scientific research paper on metal forming processes but, instead, to report the effect, application and impact of the previous and on-going metal forming related research work to the cold forming industry in China. This paper highlights the effect of 1) efficient manufacturing practices, 2) upgrading in process technology and 3)improved machines capabilities in upgrading the cold forming operation. Three real-life cold forming examples from Ritai are illustrated showing the transformation from an automotive fasteners maker into a cold formed parts manufacturer.

1. Introduction

China car industry produced 23,000,000 of cars in 2014. It is expected by 2020 some 30,000,000 cars may be built. This particular fast growing industry increases the overseas OEM and first/second tiers into China substantially over the past 20 years. Despite of the substantial increase of automotive related business revenue turnover in China, the reduction of car selling price, on the other hand causes dramatic cost reduction pressure to the OEMs and manufacturers. With the continuous changes to the social behaviour and structure, China is never a low-cost manufacturing country comparing with its neighbours. Furthermore, the overall competitiveness, technology, productivity, innovation and R&D capability do not necessary improve proportionally to the inflation of direct/in-direct labour wages, material and management cost needed for manufacturing. China is no more the heaven of labour intensive manufacturing base or low value added parts. On the other hand, the technological advancements of light-weight material, effective battery and breakthrough in car assembly and integration technology, the needs of total face-lift of manufacturing technology needed by the manufacturers and suppliers become an urgent matter. Apart from the above changes in the commercial, social, technical and supply-chain contexts, Chinese government imposes higher standard

^a Corresponding author: choycheemun@gmail.com

of environmental control, this adds pressure to the Chinese manufacturer in adopting efficiency and environmentally friendly manufacturing technique.

Automotive related industry account for substantial demands of cold formed parts and fasteners. With the above mentioned changes in the more critical business and operating environment, the Chinese home grown small and medium size enterprise (SME) for the cold forming industry needs upgrade immediately. However most metal forming R&D findings [1–3] were of lesser interest to most SMEs. The Chinese SMEs need to urgently upgrade their general automotive fasteners manufacturing techniques into manufacturing of high-strength, critical, safety and nonstandard fasteners and special parts. Despite substantial R&D work has been conducted, reported and applied in many larger and successful organisations, actual realisation in SMEs in developing and emerging countries remain challenging.

The author does not make attempt to write a scientific research paper on metal forming processes but, instead, to report the effect, application and impact of the previous and on-going metal forming related research work to the cold forming industry in China. This paper highlights the effect of 1) efficient manufacturing practices, 2) upgrading in process technology and 3) improved machines capabilities in upgrading the cold forming operation. Three real-life cold forming examples from Ritai is illustrated to show how its operation is transformed from an automotive fasteners maker into a cold formed parts manufacturer.

2. Implementation of R&D achievements

Despite of substantial R&D, innovations and new inventions have been achieved and reported by research institutes and famous industrial organisations, many small and medium size enterprises in the third world or developing countries considering the above activities as luxury. Most of the cold forming factories still dependent on previously successful experiences by using trial an error methods. It is suggested that active initiative may be taken to promote and implement scientific achievements, findings and knowledge of cold forming processes to the industrial level. Ritai as a home grown SME in China takes the following approach to advance its competitiveness locally in China and as well as closing the “gap” with the leading manufacturers worldwide. It is believed that the following well established approaches are important and beneficial to most SME in the emerging countries prior to engaging cutting edge technology.

2.1 To engage into an effective, efficient and sustainable manufacturing practices with the following considerations:

- Establish a company in-house rules [4] covering manufacturing process flow, forming progression layout, tooling design, tool manufacturing, tool assembly and tool management to achieve high efficiency cold forming.
- Target at “zero” inventory” or WIP to achieve leading but not low cost Manufacturing
- Employ FEA to enable quick turnover of cold forming process layout, die assembly design. Through this numerical approach, plastic deformation rules and design feature can be categorised into database and hence avoiding over depending of expert and experience.
- Adopt and transform into environmental friendly processes [5], such as using non-phosphate base wire preparation chemical for wire drawing and hence eliminating the need of dephosphating cold formed parts before heat-treatment
- In depth and continuous training of engineers and technicians in tool setup, trouble shooting, identification of defects, problems solving and continuous improvement. This is particularly the case for countries with large turnover of workforce.

- Make all possibilities in the localisation of wire materials. Special effort is needed to understand the local wire materials compositions, microstructures, work hardening characteristics, surface conditions and etc.

2.2 Continuous upgrading of process technology:

- Aim at operating the cold forming machines at the maximum production speed by trouble shooting the forming process design, wire conditions, tool design and construction and correct tool setup.
- Extend tool life using concept of reduction of maximum forming force [6], even material flow and die filling, minimise stress concentration on tool using segmented carbide tool design and using relevant tool coating, such as TiN.
- Achieve sustainable, repetitive, high precision & consistency cold forming process using process monitoring control to monitor the tool condition and product quality via process signatures, deviations and trends.
- Eliminate secondary processes through Net shape forming with complex features. This is made possible through good wire conditions, optimised tool design, forming lubricants and right setup and process monitoring.
- Tool design with the concept of recyclable and Inter-changeability of carbide tool to cater for high-mixed and low volume production demands. This demands high accuracy of tool manufacturing for Inter-changeability for tool replacement.

2.3 Improved machines capability and interfaces:

- Adopt to quick-die-changes to reduce setup time and eliminate human error; this demand high level of tool manufacturing, preparation and management. It also requires prior establishment of tool design and process standardisation before quick-die-change can be used effectively.
- Forming machine with high rigidity is needed for forming of hard-to-form material, repeating high dimensional stability and as well as for extending tool life. Substantial elastic deflection during forming may result in pre-matured tool wear and breakage.
- Man-Machine Interface using process signature monitoring is already matured and it is well implemented factory wide. Previously tool setup and quality monitoring control were heavily dependent on skilled workers in which knowledge and judgment are subjective and non-transferrable. With the aid of process monitoring as indicators, deviation due to setting up with different workers can be reduced substantially, hence resulted in more repetitive and consistency product quality.

Despite of none of the above mentioned practices are considered as “new” or “Cutting edge” technology, any organisation which consider them as “luxury” should treat them as “New Challenges” to metal forming processes. With the above three major measures of 1) manufacturing practices, 2) process technology and improved machine capability, an optimised 5 Ms (Man, Machine, Material, Method, Management) will not only maintain a company competitiveness but will also enable it to prepare and engage in the future cutting edge technology. Apart from net shape, complex and high precision parts, the above measures are also essential to cater for forming of high-strength low-weight hard material, such as Titanium and high nickel heat-resistant materials.

3. Illustrations of complex cold formed parts

Tool design for general nonstandard automotive fasteners and cold formed parts with simple geometry generally does not require critical considerations for process layout and tool design (Fig. 1). However, in case of cold forming of complex parts (Fig. 2) with special features, indepth knowledge of

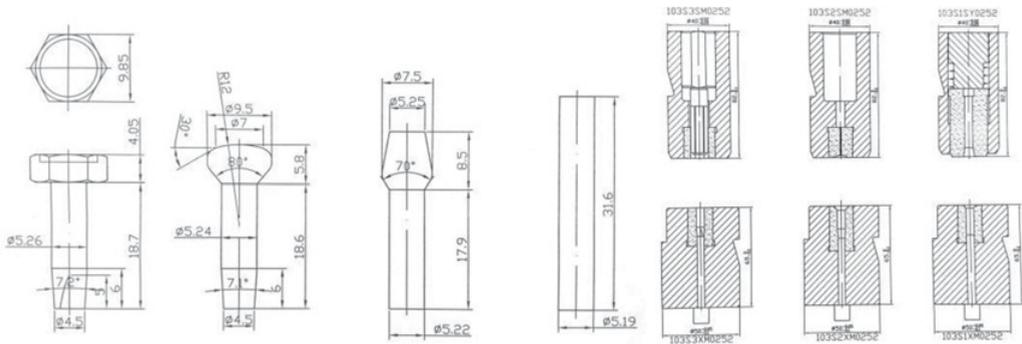


Figure 1. General Automotive Fasteners tool and process design (provided by Ritai).



Figure 2. Automotive Cold Formed Parts (provided by Ritai).

plastic deformation and application of tool design rules are required for optimised production. The following are some real-life industrial examples illustrating different considerations which are needed for successful cold forming applications. The following examples suggested that with the availability of right technology and knowledge, traditional fasteners makers such as “Ritai” can transform itself into a special cold formed parts manufacturer.

3.1 Process layout for part with large deformation

The forming of component required large plastic deformation (Fig. 3) shows that customised-in-house design rules are needed for initial wire selection and respective forming ratio at each progressive forming station. This particular component (Fig. 4) demonstrates an extreme reduction ratio in forward extrusion, upsetting and backward extrusion of up to 75%. Shall there be no company internal rules and regulations and as well as any understanding of deformation theory, the deformation ratio of forward extrusion and upsetting may vary in between 25% to 75% (Fig. 5); this may result in poor material flow, forming cracks and premature tool failure. Forward extrusion with 75% reduction allows the use of larger wire size and hence enable a lighter upsetting at the next stage; this may cause substantial wear on the forward extrusion die. On the other hand, open extrusion with 25% reduction may result in buckling and shear fracture during upsetting. The selections of the amount of extrusion and upsetting deformation, in this



Figure 3. Cold formed Parts with large deformation (provided by Ritai).



Figure 4. Cold formed Parts with extreme localized forward, upset and backward extrusion.

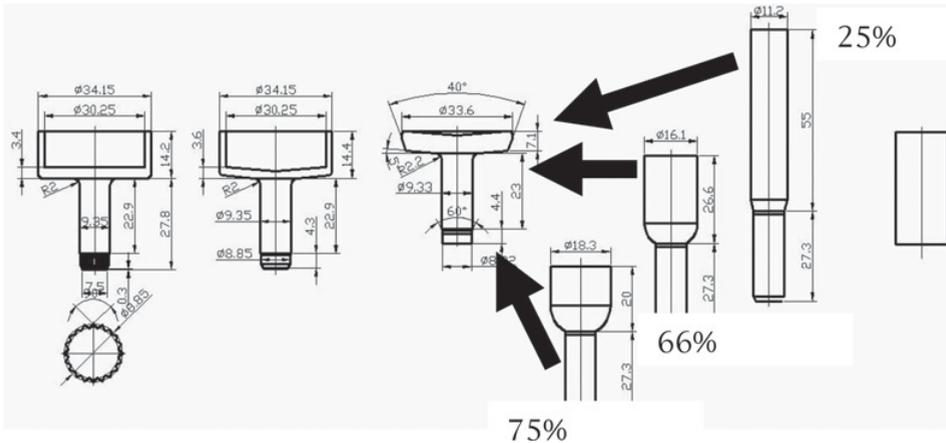


Figure 5. Process Selection based on deformation Ratio and wire diameter.

case, shall be based on the material characteristics, tool design practises and standard available wire sizes from the existing stock. It is therefore understood that the in-house established process & tool design rules are as critical parameters for an optimised, stable, effective cold forming process.

3.2 Tool design for complex part with high forming stress

The cold forming of an automotive safety belt retractor gear component (Fig. 6) combines upsetting and backward extrusion with inner and outer serrations in a single forming stage. The combination of both the upsetting and extrusion in a single forming stage is to avoid part rotation during finger transfer from one station to another. However, substantial high forming pressure caused by the combined processes during forming required careful segmentation of carbide tool piece (Fig. 7) to eliminate

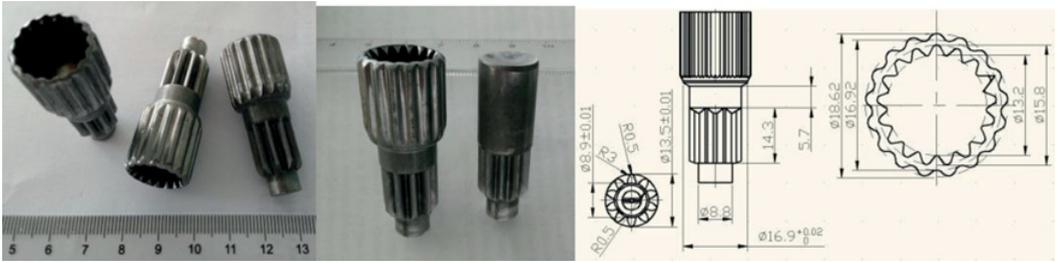


Figure 6. Combines Upsetting and Backward Extrusion with Inner and Outer Serrations in a Single Forming stage.

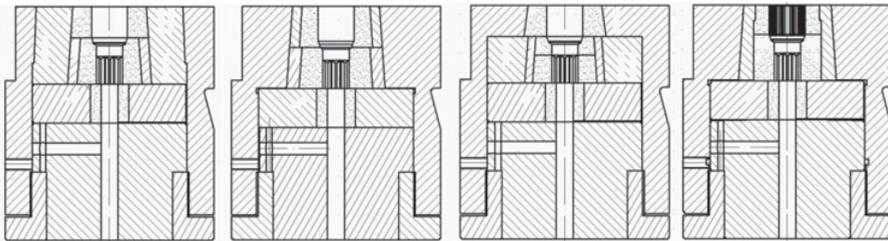


Figure 7. Different Type of Carbide Segmentation with Pre-stressed Casing.

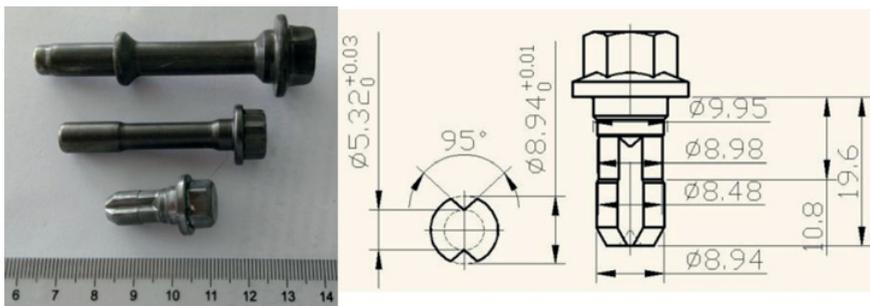


Figure 8. Smaller Shank Diameter in between the two ends of a Cold Formed Fasteners.

stress concentration and elastic deformation to the die assembly. Unlike conducting experiment in the laboratory, apart from optimising tool stress distributions during forming, die design should be carefully considered enable effective tool manufacturing, assembly, maintenance and replacement. The successful mass production of this component mainly dependent on 1) fully annealed wire, 2) right segmentation of carbide die piece, 3) polishing of die surface, 4) right amount of lubricant and 5) tool setting. Actual production results in Ritai show that, an optimized segmentation carbide tool piece can improve tool life up to three times.

3.3 Cushion integrated die space for segmented tool design

In case of cold formed products required a smaller shank diameter (Fig. 8) in between the two ends of a cold formed fasteners or parts, a segmented die design is needed (Fig. 9). During cold forming operation,

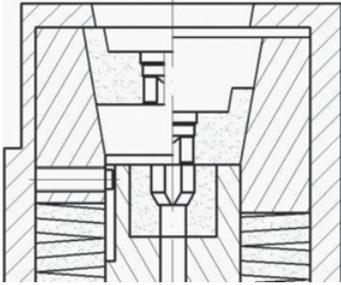


Figure 9. Typical Segmented Die Design.

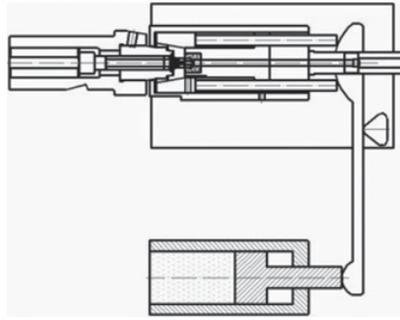


Figure 10. Forming Machine with Integrated Hydraulic.

the displacement of punch assembly with the counter spring force at the main die close up the segmented dies to effect forging. Upon the completion of the die filling in the enclosed segmented die assembly, the machine ejectors and counter die springs forces open the segmented dies and discharge the part from the die assembly. Due to the limited die space in the horizontal part forming machine, insufficient counter spring force often resulted with burrs formed on the shank surface. Forming of a complex part in Fig. 10 shows that forming machine with integrated spring cushion in a small die space is needed to effect complete die filling with minimum burr formation. Apart from FORMAX PLUS machine supplied by National Machinery, forming machine with integrated hydraulic or spring cushions is uncommon. Shall this sort of integrated cushion be available in horizontal forming machines, the use of nitrogen gas-springs and disc springs can be eliminated.

It must be stressed that the above three illustrations are only considered as New Challenges to automotive fasteners manufacturers particularly from the emerging and developing countries. However, the involvement of the technologies used in the above applications will lead to higher level of collaboration with research institutes locally and globally and as a result will develop into new technology.

4. Conclusions

Traditional cold forming companies should continuously engaging in upgrading its 1) manufacturing practices, 2) process technology and improved machine capability to optimised 5Ms (Man, Machine, Material, Method, Management) for maintaining company competitiveness and future R&D. Three illustrated cold forming examples suggested that with the availability of right technology and knowledge, traditional fasteners makers such as “Ritai” can transform itself into a special cold formed parts manufacturer.

References

- [1] Taylan Altan, Gracious Ngaile, Gangshu Shen, Cold And Hot Forging: Fundamentals And Applications, ASM International (2004)
- [2] Engel, U., Groenbaek, J., Hinsel, C., Kroiß, T., Meidert, M., Neher, R., Rächle, F., Schrader, T.: Tooling Solutions for Challenges in Cold Forging. UTFscience (2011)
- [3] Mark Gariety, Gracious Ngaile, Taylan Altan, Evaluation of new cold forging lubricants without zinc phosphate precoat, Machine Tools & Manufacture, 2007

- [4] H. Longa, D.J. Mynors, P. Holland, P. Standring, Knowledge-based process selection for rotationally symmetric and rotationally non-symmetric components in cold forming, J Mat Process Technology, 2002
- [5] M. Arentoft, N. Bay, P.T. Tang, J.D. Jensen, A new lubricant carrier for metal forming, CIRP Annals - Manufacturing Technology, (2009)
- [6] K Kondo, Precision cold forging and new shearing process, Gintic Technical seminar, (2000)