OPTIAML DESIGN OF STAINLESS STEEL DRAWING DIE BY CYBER-PHYSCICAL INTEGRATION

Walsin Lihaw Corporation

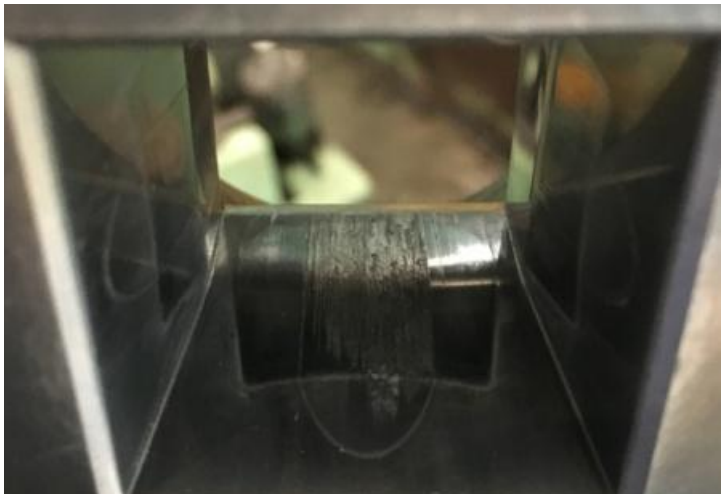
Lu, Meng-Han*; Yang, Po-Jung; Wu, Cheng-Han

華新麗華股份有限公司

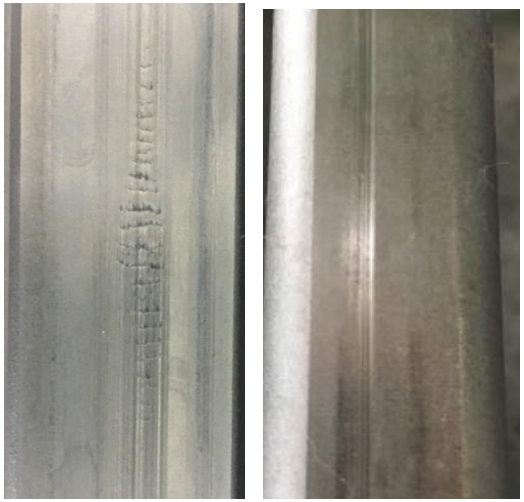
B級:機密資料

Introduction

- **During the producing process of the cold-drawing square or hexagonal bar, the uneven of deformation, and the partial large area reduction rate often cause the surface to be scratched. When the defects occur, it also causes damage to the die and reduces its service life.**



▲ The defect of the die in the inner hole



(a) (b)

▲ The defect of the cold-drawing bar surface

(a) Crack

(b) scratch

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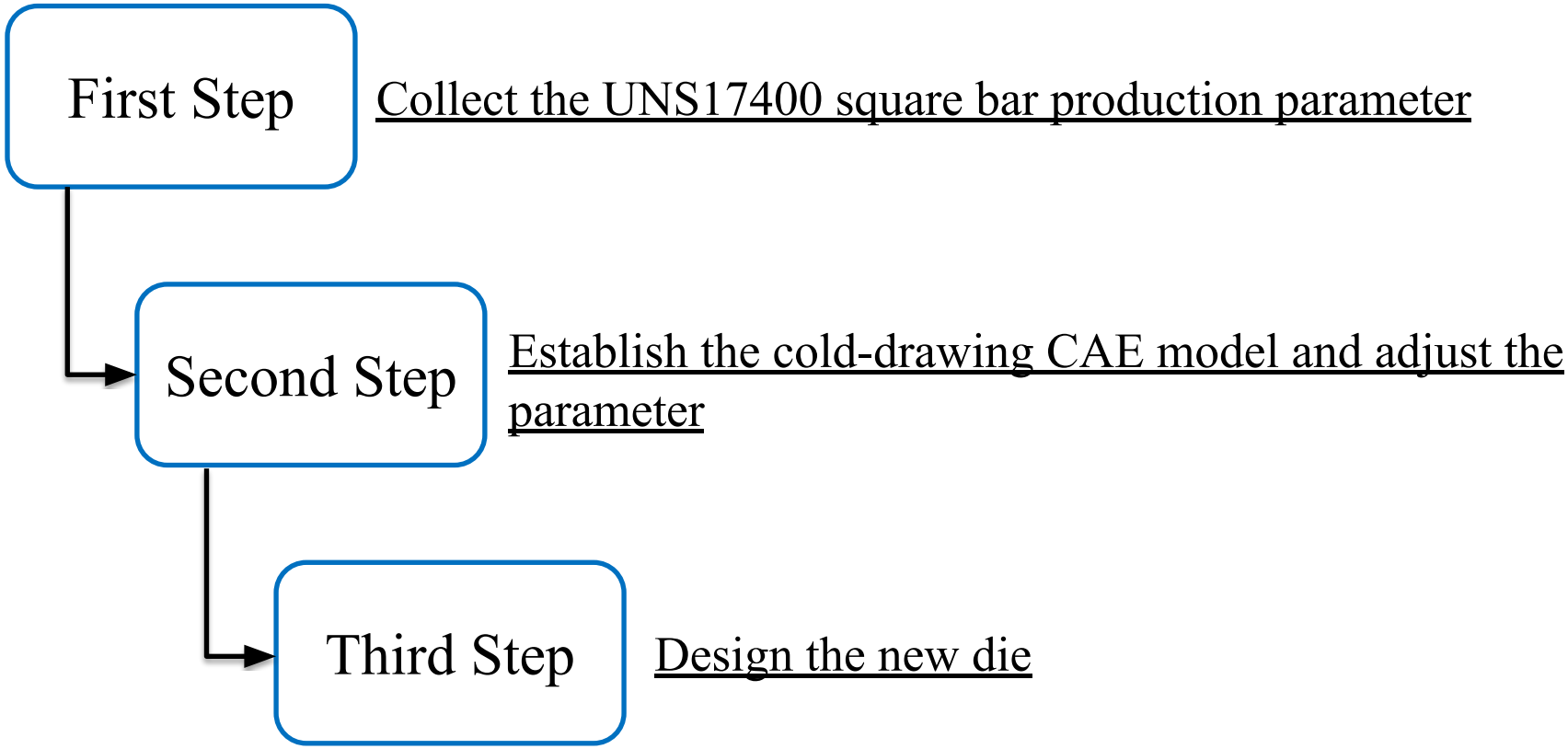
Experimental

This study is based on the UNS17400 square bar as the producing process and going for three steps.



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First Step : Collect the UNS17400 square bar production parameter

- **Table 1 show that UNS17400 with high strength and poor toughness will let cold-drawing more difficult than 300 series stainless steel.**
- **Table 2 show that the test results with different parameters of S17400 cold-drawing.**
- **The test results are using the dies before optimizing.**

▼ Table1：Mechanical properties of UNS17400 and 300 series stainless steel

Steel serious	UNS 17400	AISI S30300	AISI S31630	AISI S30407
TS (MPa)	1038	584	514	603
YS (MPa)	819	246	210	294
EL (%)	16	47	51	60
RA (%)	61	52	80	74

▼ Table2：Parameters and measurement results of UNS17400 cold drawing hexagonal bars before optimize design

Workpiece size	Cold-drawing size(mm)	Reduction angle(°)	Speed (mm/s)	Surface quality	Temperature (℃)
R33	H28.54	16	10.8	No scratch	**100**
	H28.54	16	11.2	No scratch	**110**
	H28.54	16	37	Scratch	**130**
	H31.75	18	40	Scratch	**77**
	H30.42	18	40	Scratch	**101**
	H32.15	20	40	Scratch	**78**

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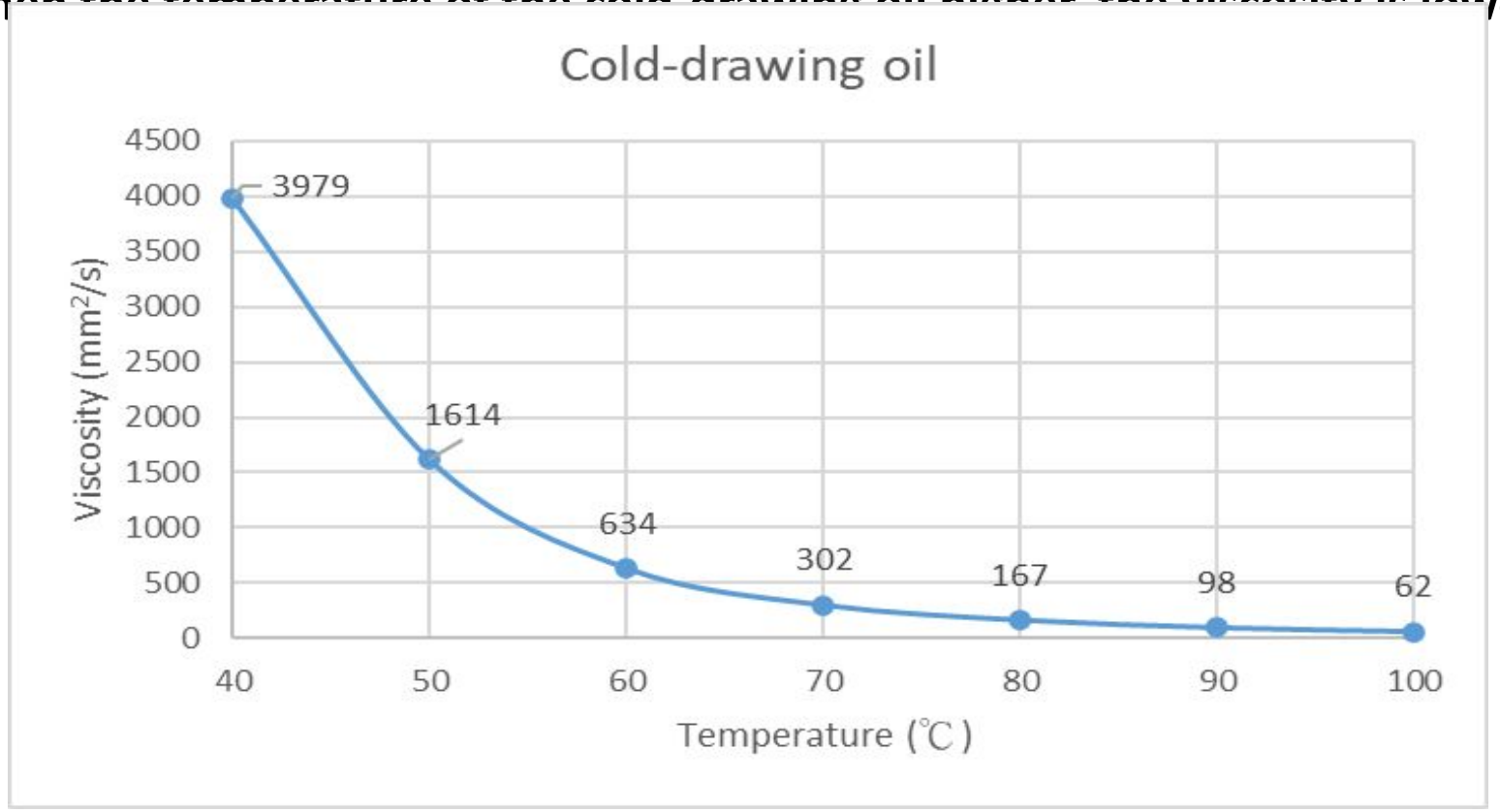
First Step : Collect the UNS17400 square bar production parameter

- The characteristic of cold-drawing oil affects the quality of the cold-drawing.
- When the temperature of the cold-drawing oil higher, the viscosity is lower.

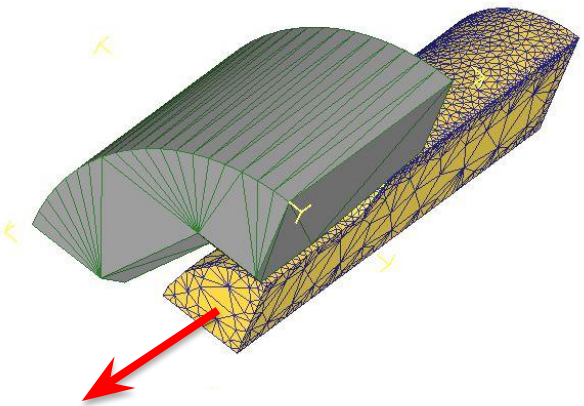


▲ The relationship between viscosity and temperature of Cold-drawing oil

Second Step : Establish the cold-drawing CAE model and adjust the parameter

- **Geometric Description**
  - Die : Actual die size
  - Workspace : R33mm
- **Material Description**
  - Die : Rigid
  - Workpiece : Plastic

    UNS17400 (Output from JMatPro)
- **Mesh Description**
  - Encryption outside feeding



▲ Quarter model of geometry

Second Step : Establish the cold-drawing CAE model and adjust the parameter

Comparison of simulation results

- Take temperature as a comparison index to verify the CAE model correct or not.
- We built a cold-drawing model which can apply in the real test

▼ Comparison table of actual and simulation results

Workpiece size	Cold-drawing size(mm)	Reduction angle(°)	Speed (mm/s)	Surface quality	Temperature(℃)	Simulation Temperature(℃)
R33	H28.54	16	10.8	No scratch	100	107
	H28.54	16	11.2	No scratch	110	110
	H28.54	16	37	Scratch	130	131
	H31.75	18	40	Scratch	77	85
	H30.42	18	40	Scratch	101	105
	H32.15	20	40	Scratch	78	88

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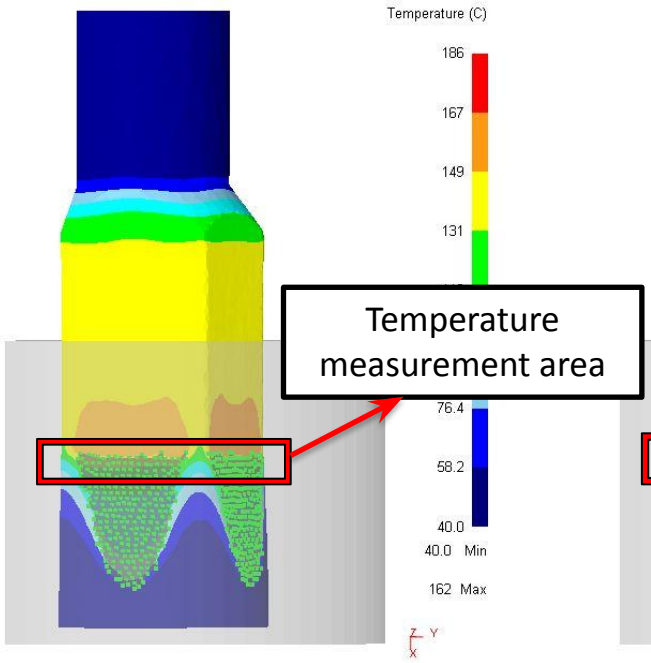
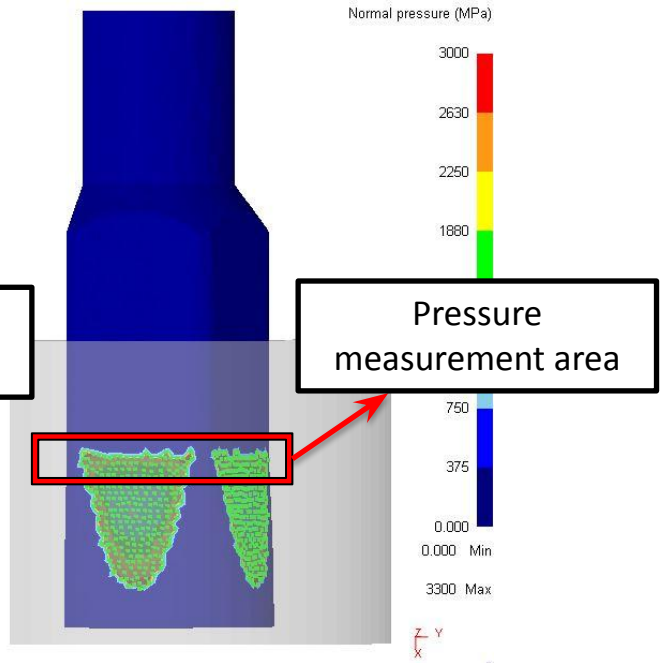
Second Step : Establish the cold-drawing CAE model and adjust the parameter

- The cold-drawing oil evaluation index are temperature and pressure. The critical value was built to avoid the scratches.
- The temperature effects the performance of the cold-drawing oil, and the pressure effec



▲ Transition zone measurement method of simulation temperature

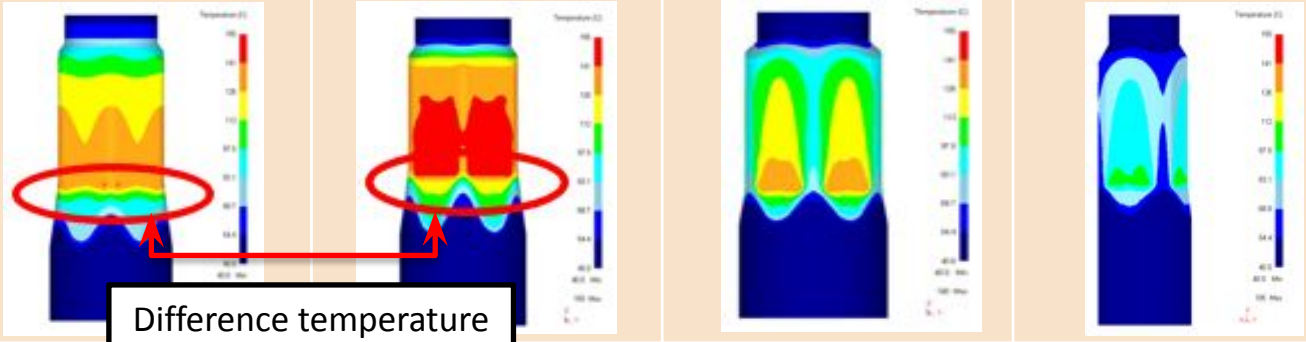
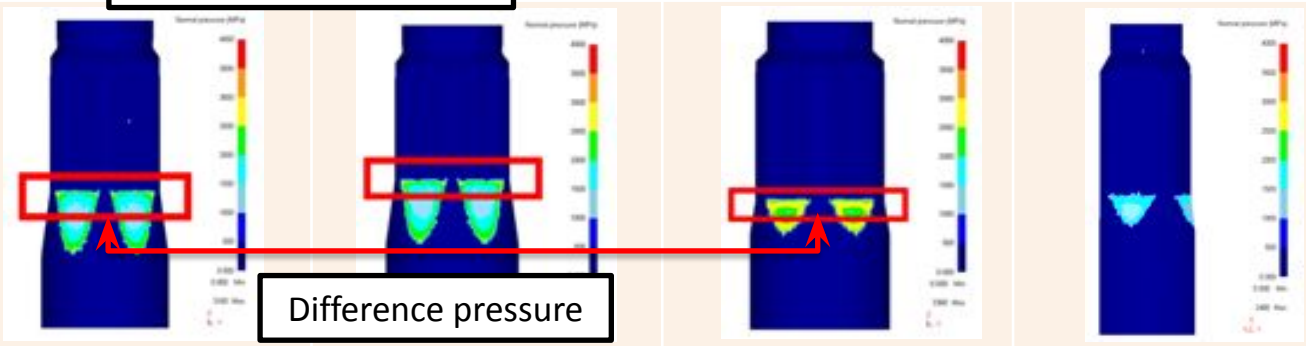


▲ Transition zone measurement method of simulation pressure

Second Step : Establish the cold-drawing CAE model and adjust the parameter

Analyze the simulation results

There are the simulation results with different parameter

	UNS17400 Simulation results of non-scratch parameter	UNS17400 Simulation results of scratch parameter	UNS17400 Simulation results of scratch parameter	300 series Simulation results of non-scratch parameter
Temperature				
Pressure				

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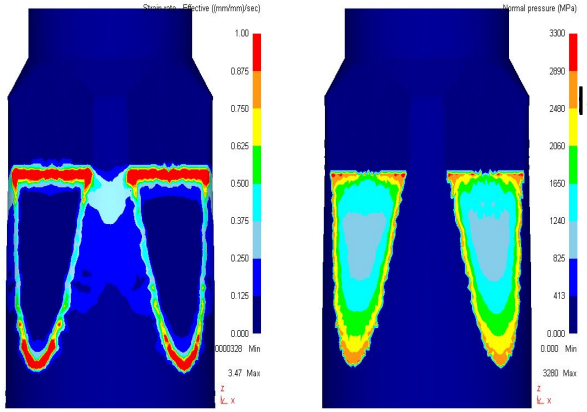
Third Step : Design a new die

- **The pressure and strain rate are concentrated at the corner. Both decrease from the outside to the inside gradually.**

- **The key to the design are:**

  - Avoid the pressure concentrating in a small area which cause the oil film failure
  - Reduce the temperature l-drawing oil.



(a) (b)

▲ Simulation results of the past design
(a) : The distribution of the strain rate (b)
: The distribution of the pressure

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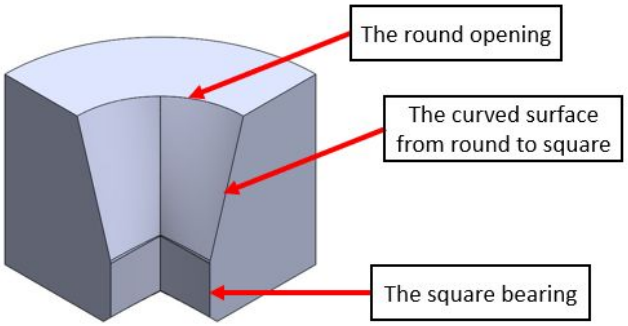
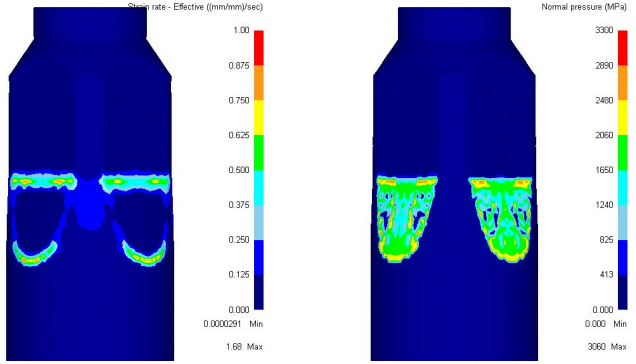
Third Step : Design a new die

- **Applied the concept of the curve to the die. The bar deformed from a round bar to a square bar gradually by increasing the contact area during the actual cold-drawing process.**

- **The uniformity of the strain rate and the distribution of pressure had improved, and the overall value decreased. The maximum pressure was within the assessed safety threshold.**



▲ Quarter model of new design



(a) (b)

▲ Simulation results of the new design
(a) : The distribution of the strain rate (b) : The distribution of the pressure

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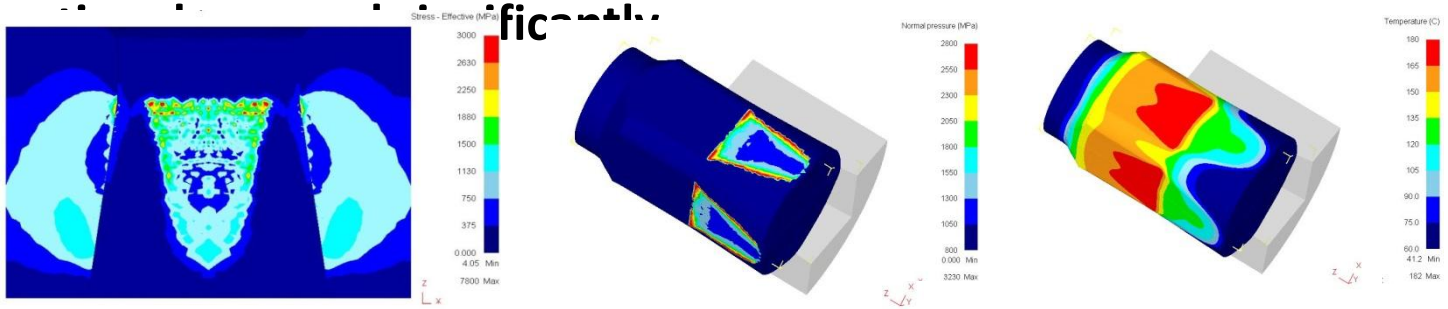
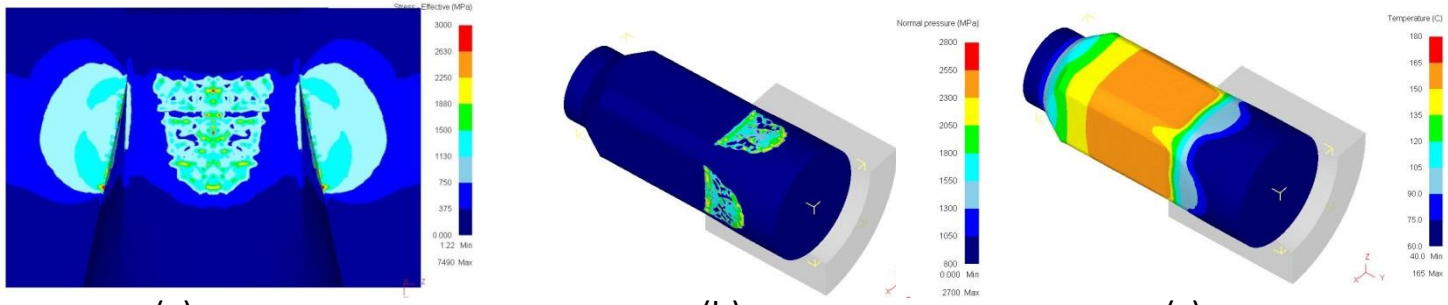
Third Step : Design a new die

- **Compare the past design with the new design, not only improved the pressure distribution, but also the heat of the material which generated by deform[illegible]ificantly**



(a) (b) (c)

▲ Simulation results of the past design
(a) : The distribution of the strain rate
(b) : The distribution of the pressure
(c) : The distribution of the temperature



(a) (b) (c)

▲ Simulation results of the new design
(a) : The distribution of the strain rate
(b) : The distribution of the pressure
(c) : The distribution of the temperature

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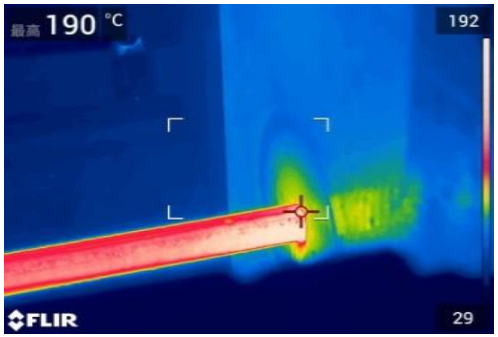
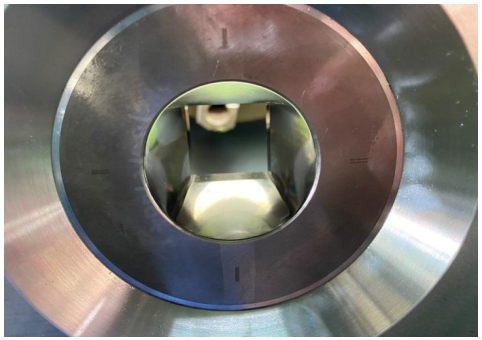
Result and Discussion

- **Compare the past design with the new design, the heat of the material which generated by deformation decreased from 190℃ to 170℃. The new design with fewer scratches than the past design.**

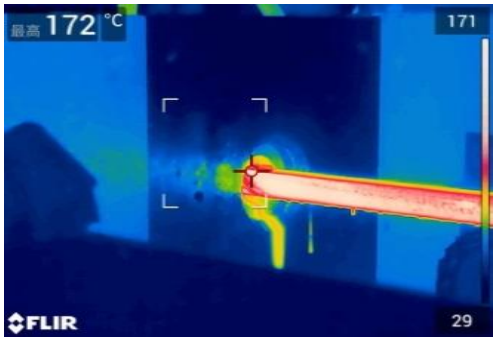
- **The service life of the new design was expected more than twice of the past.**



▲ The cold-drawing temperature of the past design



▲ The new design of die



▲ The cold drawing temperature of the new design

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Conclusion

- According to the actual test, the temperature generated from the cold-drawing deformation and the contact pressure are the key factors of the cold-drawing oil failure.
- As the results of simulation, adjusting the design of the die can distribute the deformation of the forming process. It improves the quality of cold-drawing, and the life of the die.
- The new design of the die also can apply in other stainless steel grade. It can improve the life of die effectively.
- The new die has a special curve structure in the inner hole, so the processing and the acceptance check are much complex than the past design.

Literature

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Thanks for listening ～

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