

Fragmentation behaviors and mechanical properties of the

tritium breeder pebble bed for fusion blanket

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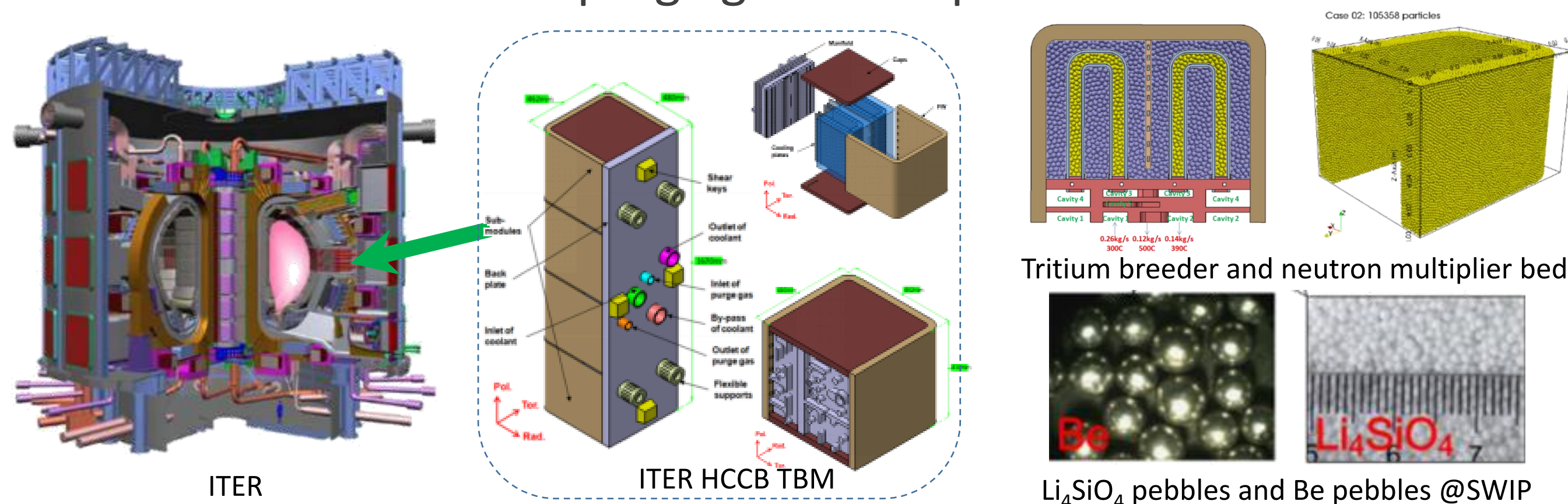
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ABSTRACT

- Fabrication and characterization of the tritium breeder Li_4SiO_4 pebbles were summarized.
- Mechanical properties and fragmentation behaviors of ceramic tritium breeder pebbles were investigated. The effect of pebble size and holding temperature on the crushing load were analyzed in detail.
- Effect of bed dimension and pebble size distribution on contact force distribution and packing behaviors were investigated.
- Flow characteristics (pressure distribution and velocity) of helium in pebble bed and its influence factors were analyzed by the DEM-CFD.

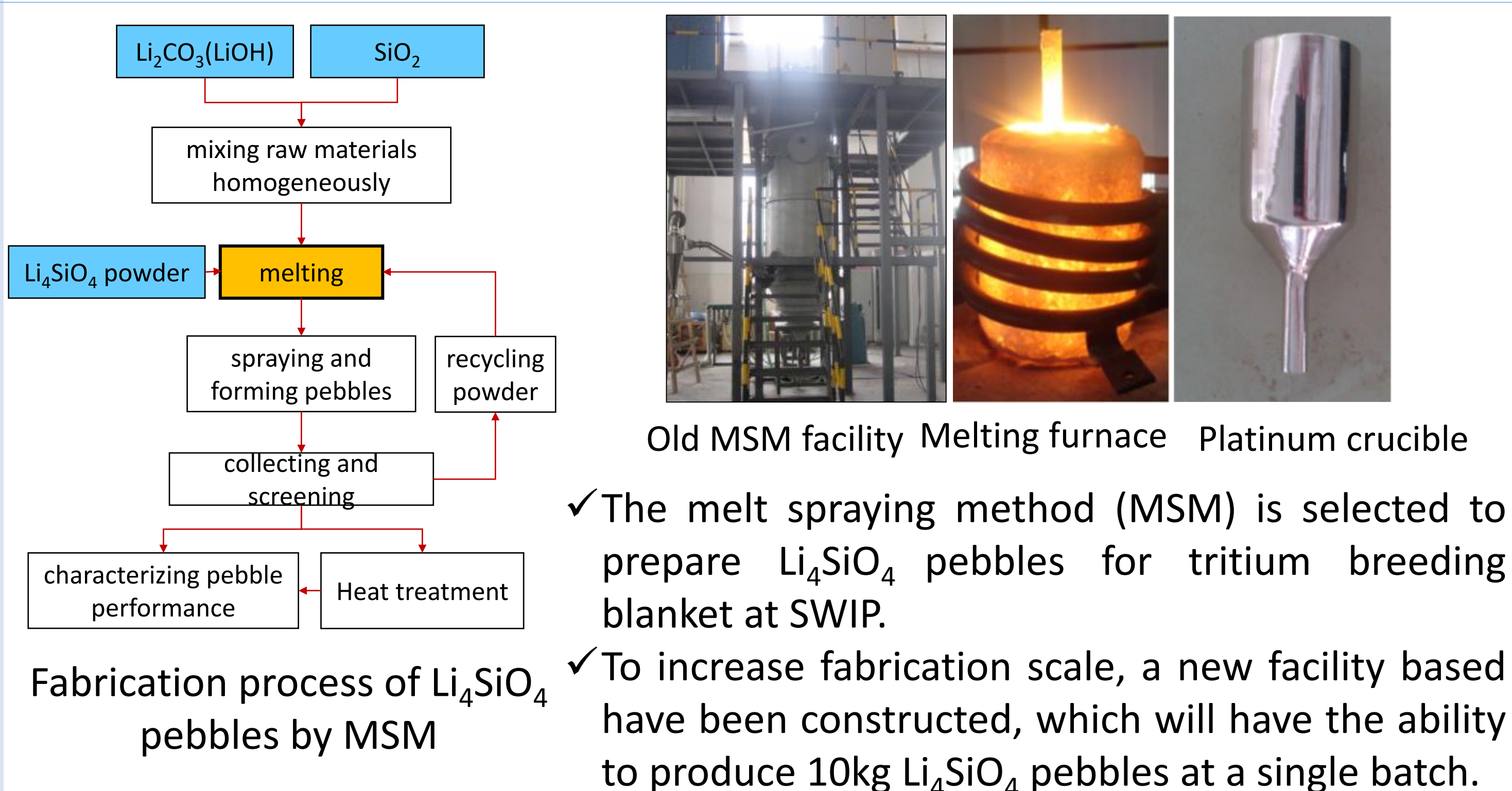
MOTIVATION AND BACKGROUND

- During the operation of the fusion reactor, Under the influence of the severe environment such as irradiation swelling, thermal expansion, alternating stress, and so forth, the tritium breeder pebbles will be broken and pulverized, accompanied by the changes in thermomechanical properties and packing structures of the tritium breeder pebble bed.
- Packing structures, fragmentation behaviors and mechanical properties, flow characteristics of the purge gas in the pebble bed.



FABRICATION AND CHARACTERIZATION

FABRICATION



CHARACTERIZATION

These Li_4SiO_4 pebbles were fabricated by melt MSM process. the diameters are about ~1mm. The pebble density are about 2.32 g/cm³, it can reach ~96% TD.

Properties	Values
Density	~96% TD
Open porosity	~ 5.2%
Closed porosity	~ 1.78%
Specific surface area	0.4626m ² /g
Average pore radius	3.674 nm

Morphology of the Li_4SiO_4 pebbles

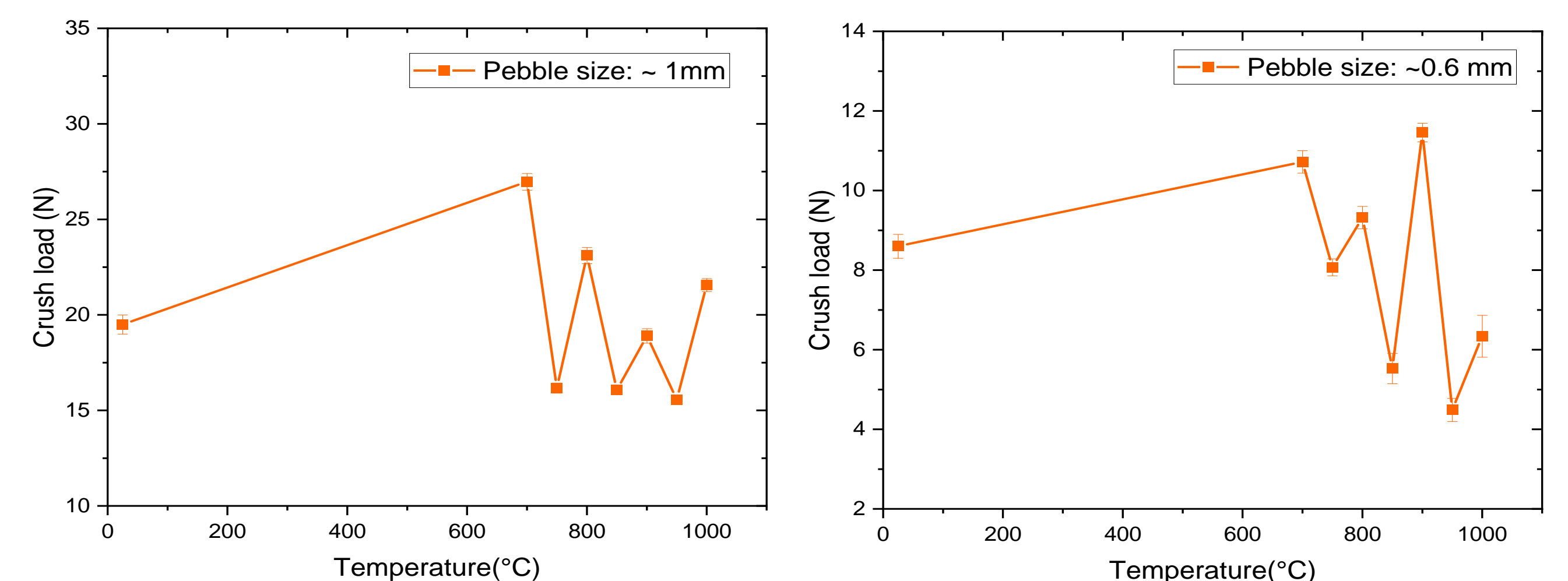
Physical properties summary

Element	Li	Si	Na	K	Mg	Ca	Sr
Content(wt.%)	21.24	21.54	0.0281	0.0393	0.0011	0.0059	0.0300
Element	V	Cr	Mo	Mn	Fe	Co	Ni
Content(wt.%)	0.0239	0.0380	0.0237	0.0183	0.0037	0.0326	0.0334
Element	Al	Zn	Cu	Ba	Ti	Zr	Pt
Content(wt.%)	0.0218	0.0234	0.0197	0.0023	0.031	0.0323	9.34 E-4

Chemical composition of Li_4SiO_4 Pebble

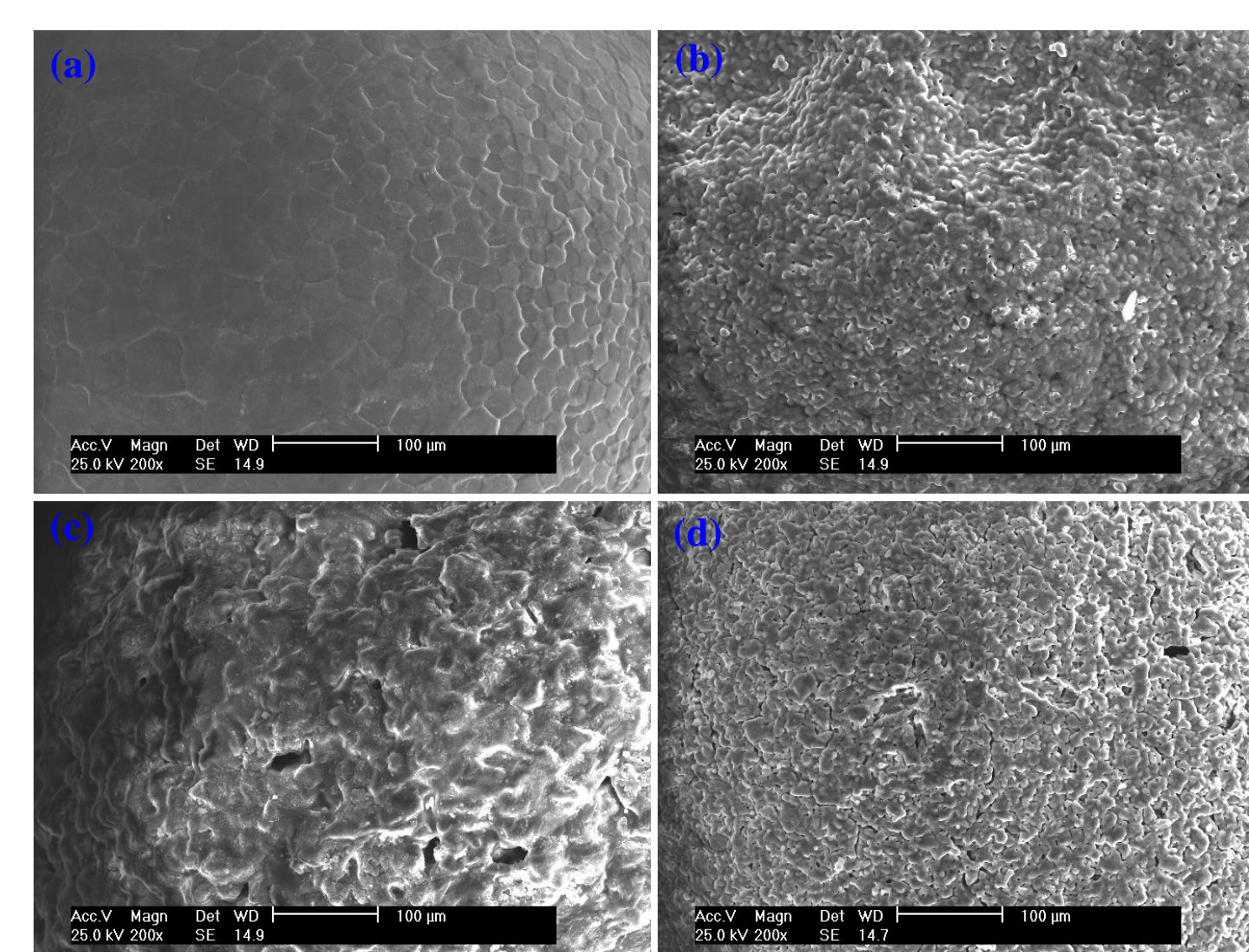
FRAGMENTATION

EFFECT OF HIGH TEMPERATURE AND PEBBLE SIZE



Effect of temperature and pebble size on the crushing load of Li_4SiO_4 pebbles prepared by the MSM process

EFFECT OF FABRICATION PROCESS



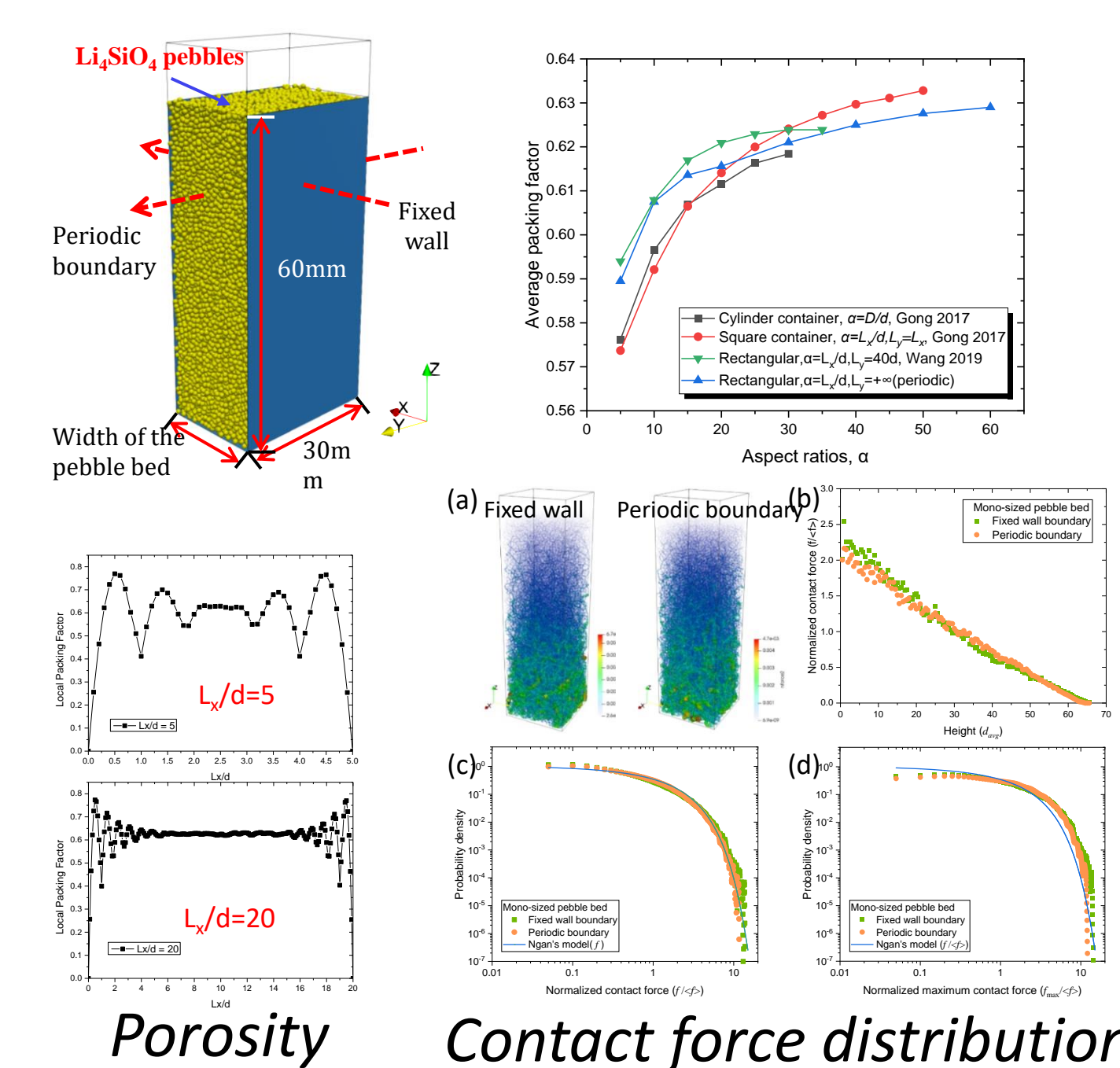
Fabrication	Avg.	Max.	Min.	Std.dev
(a)	19.56	35.64	10.03	7.19
(b)	10.18	19.22	6.49	3.63
(c)	10.39	30.57	6.60	5.26
(d)	11.99	32.74	6.79	5.65

- (a) melt spray method;
 (b) extrusion-spheronization method;
 (c) sol-gel method;
 (d) indirect wet method.

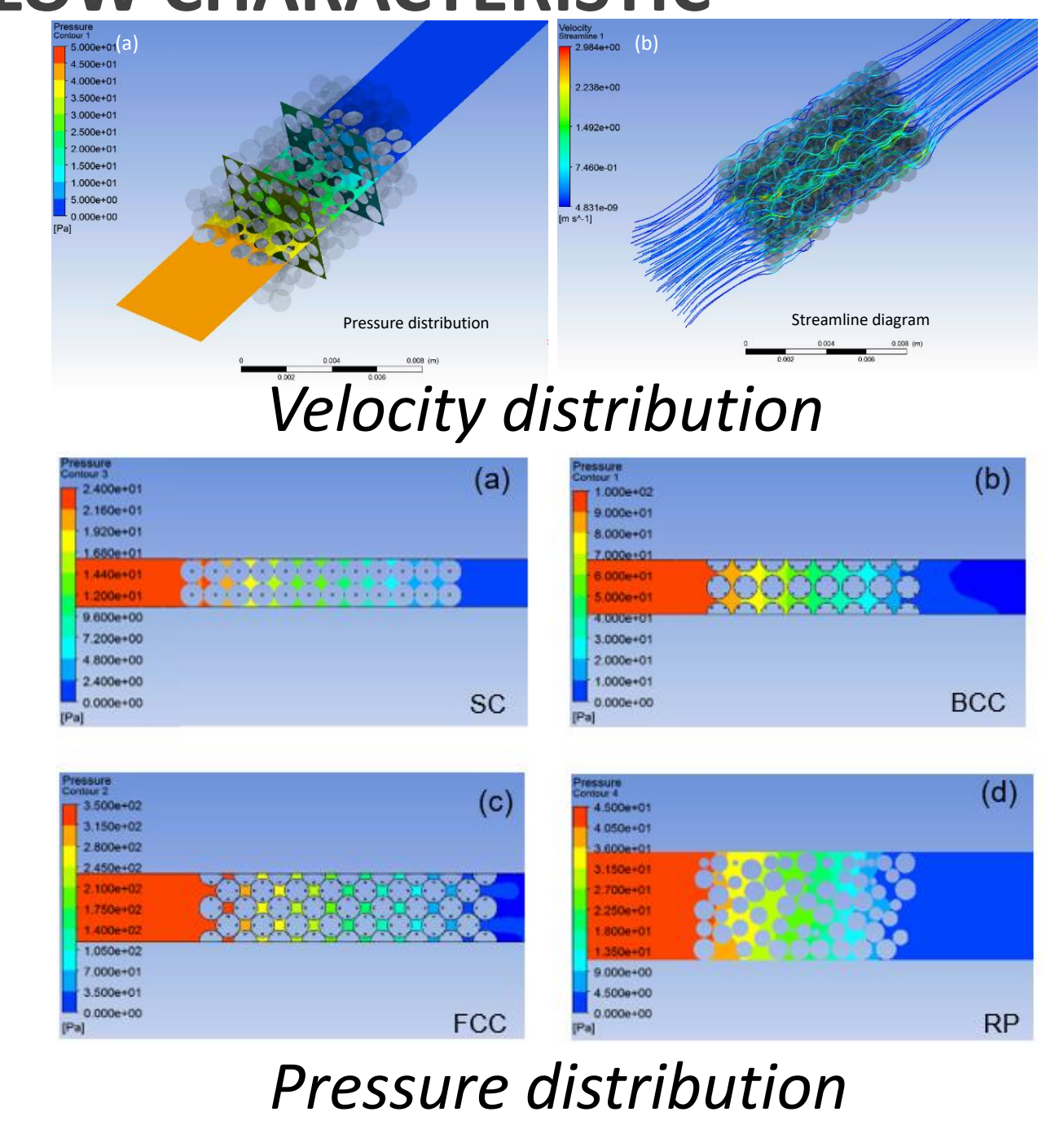
- **Temperature effect:** With the increase of thermal treatment temperature, the crush load of Li_4SiO_4 pebbles increase first and then decrease. Similar trend can be observed for pebbles with different pebble size.
- **Pebble size effect:** the larger the pebble size, the greater the crush load.
- **Fabrication process effect:** Fabrication processes have obvious effect on fragmentation behaviors (such as crushing load) of Li_4SiO_4 pebbles.

PACKING BEHAVIORS & FLOW CHARACTERISTICS

PACKING BEHAVIORS



FLOW CHARACTERISTIC



CONCLUSION

- The Li_4SiO_4 pebbles can be scaled fabricated by the new facility based on melt spraying method in SWIP.
- Pebble size, fabrication process, high temperature and holding time have significant effect on the fragmentation behavior and mechanical property of the tritium breeder Li_4SiO_4 pebbles.
- Contact force distribution and packing structure of pebble bed is influenced by the pebble size distribution, bed width and length, container shape, dimension ratio of container to pebble, vibration, etc..
- Packing structure and gas velocity have significant influence on flow characteristics of helium in beds.

ACKNOWLEDGEMENTS / REFERENCES

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